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A Successful Exhibit

ONE of the most interesting evidences of the value of the exhibit to the members of the Railway-Supply Manufacturers' Association is afforded by the experience of the exhibitors in Machinery Hall. Up to and including yesterday afternoon, forty machine tools, which, at a conservative estimate, represent a total of over $150,000 had been sold, and will be delivered following the close of the exhibit. This, it must be remembered, is a mere by-product and in no way can be considered as a measure of the value of the exhibit. The real results of the exhibit are indirect and are immeasurable in any concrete sense. The opportunity afforded by the gathering at one time and in one place of nearly 3,000 railway officers and supervisors to demonstrate the value of the most modern shop equipment, the best types of locomotive and car appliances and the latest refinements in car and locomotive design is a tremendous factor in hastening the ultimate use of these facilities. This means business for the exhibiting companies, but what in a broad sense may be considered of even greater importance, it means a hastening of progress in the development of American railroad transportation.

Long Mileage vs. Low Locomotive Maintenance Costs

THERE is considerable difference of opinion as to the extent to which mileage should be allowed to accumulate before locomotives are taken into the back shop for classified repairs. Some mechanical department officers advocate extending this mileage as far as reliability of service will permit, while others maintain that the much more frequent breaking of mileage is advisable in order to keep down the amount of the repairs which must be taken care of in the roundhouse. It is difficult to arrive at any satisfactory determination of the economic balance between the frequency of classified repairs and the amount of running repairs. Classified repairs at the back shop are allocated to each individual locomotive. The cost of individual classified repairs is therefore well known. In the case of running repairs, however, the expenditures are not accumulated by individual locomotives and the only figure that is usually available is an average obtained by dividing the accumulated maintenance expenditures by the number of locomotives maintained. It is therefore quite natural, in any consideration of this subject, more weight should be given to the cost of back shop repairs, because these are known for each locomotive and it is evident that an increase in the frequency of classified repairs will increase the annual amount of this cost. The effect on the average cost of running repairs per locomotive of running out long mileage, however, is to a large degree concealed in the average. The tendency is, therefore, to give undue weight to the cost of classified repairs, with the result that the actual overall cost of maintenance per locomotive per year may be considerably higher than would be the case if the increasing cost of running repairs as mileage accumulates were clearly reflected by individual locomotives. In one case a study indicated that it cost a railroad more than $10,000 for a single locomotive, in 200,000 miles of operation, over what would have been required had the locomotive been shopped after each 60,000 miles instead of being shopped after each 100,000 miles.

Analyse the Cost of Turning Engines

STUDIES have indicated that the average labor cost of turning power at engine terminals is about six cents a mile, or four dollars an engine, depending upon the distance between terminals, kind of handling facilities available, and other conditions. The elements which go to make up enginehouse expense as prescribed in the federal classification are: Miscellaneous handling, involving moving over turntable, calling engine crews, drying sand, etc.; cleaning or knocking fires; cleaning locomotive exteriors; washing boilers, which includes washing the insides of tanks and changing water; cleaning flues; applying oil and grease; building fires and watching locomotives in the enginehouse, and hostling expense. By checking the time required for each of these operations at any particular terminal with that for similar work at other terminals on the same or other roads, possible improvements usually suggest themselves. One large railroad followed this practice of analyzing and improving enginehouse operations on the system and, as a result, effected a saving of 41 per cent, or nearly one-half of its enginehouse expense, in a period of four years. As was to be expected, this road found the distance between terminals to be one of the

most important factors in enginehouse expense, and that the effect of track layout on hostling expense and flexibility of operation was highly important. Other enginehouse features, the proper attention to which greatly assisted in reducing enginehouse expense were: The arrangements for handling coal and ashes; stall and drop pit capacity; boiler washing facilities, and the machine and power trucking equipment. Fundamental improvements in enginehouse equipment and operation cannot be effected over night, and some badly needed changes in old terminals are practically prohibited on account of excessive cost of changing the original layouts. Certain improvements are possible at almost every terminal, however, and if these are made a few at a time as opportunity offers, the result is bound to be a marked general improvement in enginehouse operation, with resultant decreases in costs.

Car Wheel Grinding Advocated

THE wheel report presented Monday recommended in its closing paragraphs that the question of the advisability of grinding slid flat cast iron, cast steel and one-wear wrought steel wheels be submitted to letter ballot for recommended practice. Experience over a number of years on several roads has shown the value of this practice, and considerable discussion which followed the reading of the report was practically unanimous in favor of it. Hardly any stronger recommendation for grinding could be given than that afforded by one of the members, who said, "Trainmen in our territory all insist on having ground wheels under the cabooses, as they ride much better than with cast unground wheels, and if the riding qualities of ground wheels will save a man from jarring and jolting, they will certainly save claims when applied to box and refrigerator cars, where fragile and perishable freight is handled." It has been demonstrated that the ground wheel is superior to second-hand wheels and the labor cost of the operation is not excessive when the work can be performed in an average of 20 to 30 minutes. The grinding operation referred to consists of inserting the mounted wheels in a large stationary car wheel grinder and grinding the wheel peripheries to true circles concentric with the journals. The practice of removing single flat spots with a portable grinding machine, which simply enlarges the arc of the depression, is being considered with some favor on several roads, the claim being made that the irregularity in circumference resulting from this grinding does not exceed the irregularities in many of the wheels when new. A fair-minded and sound stand has been taken by the Wheel Committee, in advocating a neutral attitude toward this practice until it has had a chance to prove itself. It would be a mistake to incorporate partial grinding of the wheel peripheries as recommended practice until favorable results have been shown over a reasonable period of time.

Why Not Study the Utilization of Machine Tools

MUCH good work has been done by the Committee on the Utilization of Locomotives in showing the railroads of this country how they can get the best results from their power. A committee on the Utilization of Machine Tools and Shop Equipment could do much in developing the proper methods of selection, location and utilization of machine tools. This committee could either function independently or as a sub-committee of the Committee on Shops and Terminals. Its membership could be selected from the many capable machine tool experts now already deeply interested in this problem on the railroads. Many railroads have supervisors of machine tools and machine tool committees which have already compiled much informative data that would be of considerable benefit to such a committee. Much can be done as to the proper location of machine tools in the shop with respect to the location of other shops and departments. Machine tools should be considered with respect to the proper functioning of shop schedules. Much study has been and is being given to the speeding up of operations and shop schedules are now used in most of the progressive railway shops. In order to get the maximum benefits from these schedules, it is imperative that the proper modern tools be selected and be correctly located. What types of machines should be used under different conditions? Is there an economical ratio of the number of machine tools to erecting pits? What should the locomotive output be before a shop specializes its tools? These are questions that can be profitably studied by some such method as that employed by the Locomotive Utilization Committee in its work.

Another phase of the subject to be considered is the obsolescence factor for machine tools and shop equipment. On what basis should a machine tool be scrapped? Should it be based on years of service, on physical depreciation, or on improvements that are available in new tools? On what basis should old tools be transferred to smaller shops or engine terminals? Has the time arrived to consider it poor practice to send old tools to engine terminals?

The problem of machine tools is rapidly becoming one of moment with all railroads as it is imperative properly and economically to service modern locomotives and cars in order not to defeat the aims of the management in buying such equipment to reduce operating expenses. Does not a study of the utilization of machine tools and shop equipment offer a field for useful service, to the Mechanical Division?

Paper Showing

STATISTICS of performance are absolutely essential to efficient mechanical department operation. Without them no means is available of knowing what particular type of equipment or method of operation is most economical, and, with them, decisions otherwise hit-or-miss can be made with certainty. Needless to say, statistics to be of value must be accurate, unprejudiced and properly interpreted. Above all, it is important that mechanical officers seek unvarnished truth in their cost figures and that, in their ambition for creditable "paper showings," if they credit themselves with savings at the expense of some other department, they do not lose sight of conditions in their own department, the correction of which will save money for the railroad. To give a specific example, one road which was making an earnest attempt to reduce enginehouse expenses found that after preparation for service, freight locomotives and switchers were moved some distance beyond the enginehouse limits to ladder tracks at a nearby freight terminal where they were held under steam in the care of hostlers. By reclassifying and charging a portion of this expense to the transportation department, the cost of turning power at this terminal was reported to be decreased two dollars per engine turned. Admitting the desirability of a proper allocation of mechanical and transportation expenses, one thing is sure—the cost to the railroad of turning power

at terminals is not reduced by such methods. An urgent appeal should be sounded for each mechanical officer to look beyond the confines of his own department and see how his efforts are co-ordinating with those of his fellow workers in the operating, stores and other departments. Speed the day that every enginehouse foreman and master mechanic will see on the locomotive cabs, not the insignia of their own particular divisions, but the larger letters of the parent road to which they owe first loyalty! When all officers, both mechanical and operating, adopt this attitude, they will have no incentive for "paper showings" made at the expense of some other department or which tell anything but the plain, unvarnished truth.

Designing Locomotives to Reduce Track Stresses

THE progress report presented by the Sub-Committee on Designing Locomotives To Reduce Track Stresses is evident that it is doing a splendid piece of work in developing basic data for future investigations which must be carried on before the features of locomotive construction effecting track stresses can be designed intelligently to produce the least stress. For a number of years the Special Committee on Stresses in Railway Tracks of the American Railway Engineering Association has been conducting a series of tests with the assistance of such roads as the Atchison, Topeka & Santa Fe, the Chicago, Milwaukee & St. Paul, the Baltimore & Ohio, the Reading, the Lehigh Valley and the Richmond, Fredericksburg & Potomac. These tests have resulted in the accumulation of a large amount of valuable information pertaining to the stresses set up by various types of electrical and steam locomotives and cars on straight tracks and on medium and sharp curves.

Considerable work from the standpoint of locomotive design has already been done both in this country and in Europe, the results of which have been published in papers presented before various railway technical organizations or published in technical journals. Reference can be made in this connection to the paper prepared by R. Eksergian on stresses in locomotives, which was presented by the Railroad Division at the annual meeting of the American Society of Mechanical Engineers in 1921, and to an article on derailments of locomotives on curves which was published in the December, 1924, and January, 1925, issues of the *Railway Mechanical Engineer*. The conclusions in this article were the results of a series of tests and studies made by the mechanical department of the Bessemer & Lake Erie. It has been reported that the mechanical departments of a number of other roads, such as the Texas & Pacific, have also begun investigations of this problem from the standpoint of locomotive design, the results of which will be available to the sub-committee of the Mechanical Division.

The assembling of all the relevant data pertaining to the design of locomotives to reduce track stresses will entail considerable work on the part of the committee members, and in all probability they will find it necessary to check by test the separate conclusions obtained from these various sources. The ability of a locomotive to traverse curves with ease is essential in reducing the operating costs of a railroad. The work being carried on by the sub-committee, especially in its study of the design of the locomotive, should be continued and the results obtained in its investigations eventually combined with that of the special Committee on Stresses in Railway Tracks of the American Railway Engineering Association in its final report.

Today's Program

TODAY will mark the closing session of the convention of Division V—Mechanical A. R. A. The meeting will be called to order at 9.30 a. m., Daylight Saving Time. The session will probably adjourn well before the closing hour of 12.30 p. m., since the Individual Paper which was scheduled will not be presented. The program as amended follows:

Discussion of Report on:
Utilization of Locomotives.
Closing Exercises.

Entertainment

10.30 a. m. Orchestral Concert, Entrance Hall, Million Dollar Pier.

Lost and Found

SOME convention visitor lost a Knight Templar's watch charm in the room of J. D. Purcell at the Ambassador Hotel. The owner can recover it by calling at the office of Secretary Sonway.

LOST—Badges 1065 and 5244.

Registration Figures

THE registration at 4:30 Tuesday totaled 7,803. When the total attendance figures are available, it seems certain that the forecast of attendance for the 1926 conventions will have been proved conservative. The table shows comparative figures for the past four conventions.

	1920	1922	1924	1926
Division V—Mechanical	875	999	1,207	1,410
Division VI—Purchases and Stores	364	376	427	480
Special Guests	785	907	1,066	875
Railroad Ladies	798	1,008	1,178	1,191
Supply Men	2,575	2,290	2,666	3,122
Supply Ladies	676	573	675	725
Totals	6,073	6,153	7,219	7,803

Erie Apprentices Visit Convention

THE fact that the mechanical departments of the railroads are giving more and more attention to the selection and training of apprentices is again emphasized by the fact that the Erie Railroad has sent 10 apprentices in charge of the apprentice instructor to attend the convention and study the exhibits at Atlantic City. The story can best be told by the following quotation from the daily paper at Susquehanna, Pa.:

"The Erie Railroad Company has the reputation of treating employees better than any big corporation in America, and in keeping with this spirit, the "Old Reliable" is sending a number of apprentices in the Susquehanna shops on a sight seeing and educational trip.

"They will leave Susquehanna on June 14 and will be away until the 18th. They will be accompanied by H. E. Blackburn, apprentice instructor in the local shops. The apprentices who make the trip are L. A. Bevans, C. Westbrook, J. Sullivan, J. O'Neal, D. Ives, A. L. Schell, D. Vedder, V. Washburn, G. M. Scheilds, F. Munson and D. B. Taylor.

"The party will first go to Atlantic City for the Ameri-

can Railway convention. While on the trip they will visit the Baldwin Locomotive Works at Eddystone, League Island Navy Yard and the Sesqui-Centennial exposition in Philadelphia."

T. M. Price Dies

NEWS has just been received that T. M. Price, master mechanic of the Seaboard Air Line at Raleigh, S. C., died Saturday at Covington, Ky. Mr. Price's early railroad experience was on the Pere Marquette.

Entertainment Yesterday

THE social features of yesterday were marked by holding the grand ball in the evening in Entrance Hall of the Million Dollar Pier. The attendance was unusually large. It was a great compliment to the guest of honor, J. T. Wallis, Chairman, Division V-Mechanical, A.R.A. At the close of the Grand March, the Samuels orchestra, which has provided excellent music during the convention, furnished a dancing program of sixteen numbers, with liberal encores. The usual special features were dispensed with; all seemed to prefer dancing to any other form of entertainment.

For the arrangements and the success of the evening's program, credit is due to the committee in charge as follows: George T. Cooke, general chairman; Floyd K. Mays, vice-chairman; C. W. Floyd Coffin, chairman; S. L. Bateman, J. P. Bourke; A. N. Dugan; L. J. McCombs; P. L. Maury; C. R. Naylor; N. C. Naylor; L. R. Pyle; J. A. Renton; F. E. Symons; R. P. Townsend; F. W. Venton, and R. W. Williams.

Stop Off at the Sesqui-centennial

THE Sesqui-Centennial International Exposition which is going through its preparatory month prior to the official opening on July 4, has sent its director of exhibits, Axel Malm, to visit the convention of Division V—Mechanical, A. R. A., and, through Mr. Malm, the Sesqui-Centennial extends a hearty invitation to all the members of the Mechanical Division, the Purchases and Stores Division and the R. S. M. A. to visit the exposition on their way home from the convention. Instructions have been given the concessions and admissions department of the Sesqui-Centennial and each member carrying the official convention badge will be permitted through any of the gates to the exposition.

The director of exhibits announces that several of the leading industries and members of the R. S. M. A. are already erecting their exhibits, making elaborate plans for an extensive show. It is also announced that the Machinery Hall, which carries the official title of United States Government Machinery, Mines, Metallurgy and Transportation Palace, is so far completed that exhibitors may begin their installations immediately. This building presents to the world the most magnificent machinery hall ever erected, covering nine acres of land, it is fully equipped with all modern engineering features.

Conventionalities

Scott M. Rogers, vice-president of the Elgin, Joliet & Eastern, has been attending the conventions and looking over the exhibits. He has been accompanied by Mrs. Rogers.

C. W. Galloway, vice-president of the Baltimore & Ohio, and Mrs. Galloway have motored back to their home in Baltimore after having had a pleasant and profitable visit to Atlantic City on the occasion of the conventions.

Walter Doering, of the Bradford Corporation, came to the conventions two years ago from St. Louis, but he comes this year from Chicago, having recently been promoted to vice-president in charge of western sales of this company.

E. J. Pearson, president of the New York, New Haven & Hartford, was looking over the exhibits yesterday with W. L. Bean, mechanical engineer of that road. Mr. Pearson has been a pioneer in believing that the railways should engage in motor bus transportation and in undertaking to render extensively that kind of service.

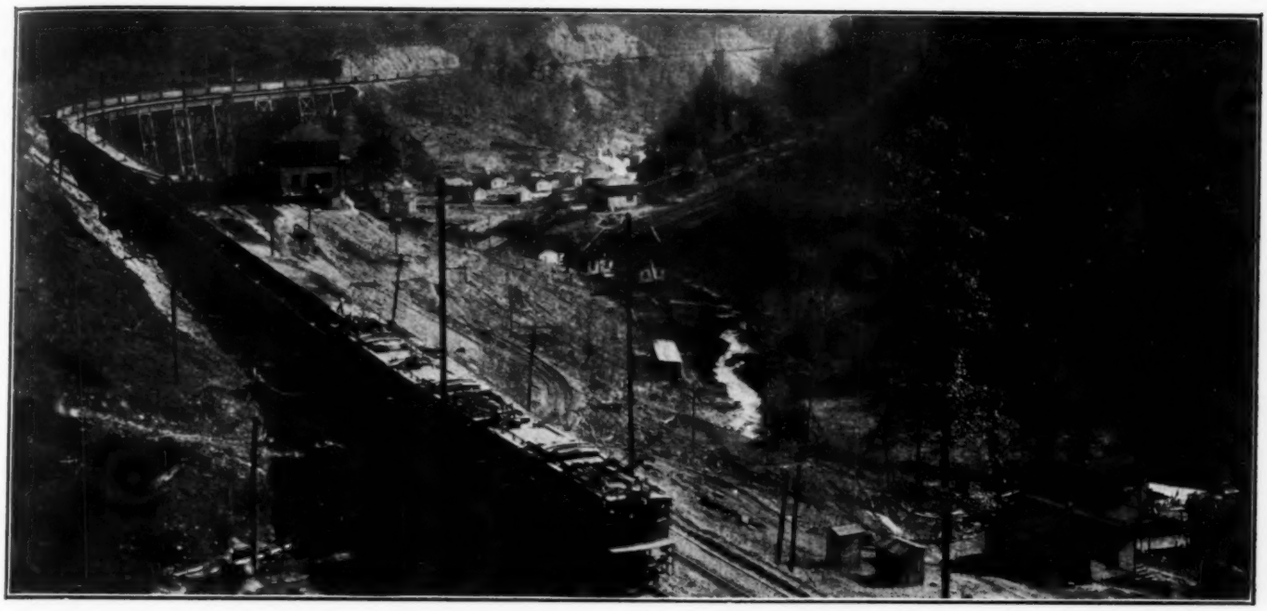
H. B. Slaybaugh is here with Mrs. Slaybaugh, for the first time as president of the American Arch Company, although Mr. Slaybaugh has been a regular attendant at the conventions for the past 25 years. His three sons, Chester, 22 years old, Ernest, 18 years old, students at the University of Pennsylvania, and Clifford, 12 years old, were at Atlantic City over the week-end.

Among those who arrived to attend the locomotive sessions this week was Joseph Chidley, superintendent of motive power, New York Central, Lines West. This gives E. A. Kuhn of the Nickel Plate, whose arrival has already been mentioned, the distinction of being probably the only man on the Pier whose father and father-in-law are both superintendents of motive power, and both of whom are here, W. T. Kuhn occupying that position on the Toronto, Hamilton & Buffalo.

Believe it or not, but Lewis B. Rhodes, representing the Vapor Car Heating Company and The Bradford Corporation, has attended every convention since 1906. Mr. Rhodes carries his years lightly, but it is evident that railway work agrees with him—it's in the family. Many present will remember his father, L. B. Rhodes, at one time superintendent of motive power of the Georgia, Southern & Florida, and later superintendent of motive power of the Virginia Railway. Later the elder Rhodes joined the Vapor Car Heating Company. L. B. Rhodes is a past president of the Air Brake Appliance Association.

According to circumstantial evidence, C. A. Odell, vice-president of the Superheater Company, Ltd., Montreal, is the champion walker of the world. According to his own statement he left Montreal Tuesday evening, June 8, with C. E. Brooks, chief of motive power, Canadian National, and William J. Casey, president, Canadian Locomotive Company. Messrs. Brooks and Casey registered at the convention Thursday, June 10, but Mr. Odell did not show up until Sunday. A great many of his friends would like to know just what mode of transportation he used in coming down from Montreal. The only way they have been able to figure out the long time it took for him to make the trip is that he must have walked.

(*Continued on Page* 1865)



Descending Clark's Gap, on the Virginian, near Covel, W. Va.

Electrical Session Held by Div. V

Fifth Mechanical Session devoted to presentation of Reports on Electric Rolling Stock and Locomotive and Car Lighting

Electrical equipment reports were presented and discussed during the fifth session of the Mechanical Division Convention which was opened by Chairman Sillcox at 9:30 yesterday morning.

After announcements by Secretary Hawthorne, the report of the Committee on Electric Rolling Stock was presented in sections by the different members of the committee.

Report of Committee on Electric Rolling Stock

Moffett Studio

L. K. Sillcox
Chairman

Under the heading "Characteristics of Electric Locomotives" the different locomotive ratings are explained and steam and electric locomotive analogies are given in steam railroad vernacular. In presenting the subject, "Probable Effect of the Height of Center of Gravity" the statement is made that this height can be varied in electric locomotive design and the report is simply an outline of how this effect may be studied both practically and theoretically. A study of variable resistance trucks shows that there are a number of new problems involved in designing electric locomotives to operate singly or in multiple unit service and at the same time give satisfactory performance when run in either direction.

Another part of the report consists of a short but comprehensive description of the Virginian electrification. This includes notes on the training of enginemen and an outline of the present method of train operation. All of the more important factors governing the selection of multiple unit electric passenger cars are outlined under the heading "The Design of Multiple Unit and Trailer Cars for Terminal Service of Trunk Line Railroads." Plans and side elevations of a number of such cars now in service are contained in the report but are not included in this abstract. The report concludes with a resumé of the progress made during the past year in the field of electric traction. This includes comments on cars and locomotives propelled by gasoline and oil engines.

Tractive Power Characteristics of Electric Locomotives

Electric locomotives have been in regular use on a large and diversified scale for a sufficiently long time, to dispel all doubt, as to their ability to give satisfactory service and to prove that they are reliable and rugged pieces of machinery rather than delicate toys. Like any other class of apparatus, however, they may be abused by mishandling; and the fact that they do not protect themselves by lying down when overloaded, and often do not even show any immediate signs of distress, renders them subject to abuse through a lack of understanding of their characteristics.

When an operating section of a steam railroad is first electrified, that railroad is going to buy some costly experience, unless certain of the inherent differences in characteristics between steam locomotives and electric locomotives, are fully recognized. The principles involved are simple in themselves, but are not self-apparent to the operating men accustomed to steam locomotives, who has not had time to study electrical equipment. Being accustomed to the thought that "what she'll start, she'll pull," he is apt to load up his electric locomotives accordingly—and then see them burn themselves up try to live up to his misunderstanding. The sustained tractive force and speed of a steam locomotive is

principally dependent on the ability of the boiler to furnish steam, in other words to "keep her hot." Contrary to this, the output of an electric locomotive depends on the ability to "keep her cool." All electrical apparatus—motors, transformers, rheostats, cables—become heated when used. If overloaded, they will overheat, the insulating materials will be damaged, and the resulting "burn-outs" will be expensive. The trouble is of a particularly insidious nature, since overheating, if not too severe, may give little external indication at the time, but internal deterioration is progressing each time overheating occurs and break-down will eventually result.

The problem of the operating man is to understand how far he can go without causing damage.

The heat in electrical equipment comes from various sources; friction of brushes on the commutator of a motor, eddy currents in the magnetic iron of motors or transformers, etc., but the predominating amount of heat in equipment carrying heavy load, is that produced by the current passing through the copper conductors. This heating always occurs when current flows through a conductor, and since it is proportional to the square of the current, it is of great importance at high currents. As long as heat is generated faster than it is radiated off to the air, the temperature will continue to rise. As the temperature of the apparatus increases, however, the rate of radiation increases and eventually a balance will be reached where the heat is radiated off as fast as it is generated. After this the temperature will not increase further. If the balancing temperature is not too high, or if the heating up process is stopped before an excessive temperature is reached, no damage will result. But if overheating occurs, the insulation will be affected; the higher the temperature reached, or the longer it is continued, and the oftener the overheating is repeated, the sooner failure will occur. In extreme cases, solder may even be melted out of connections, and immediate failure result.

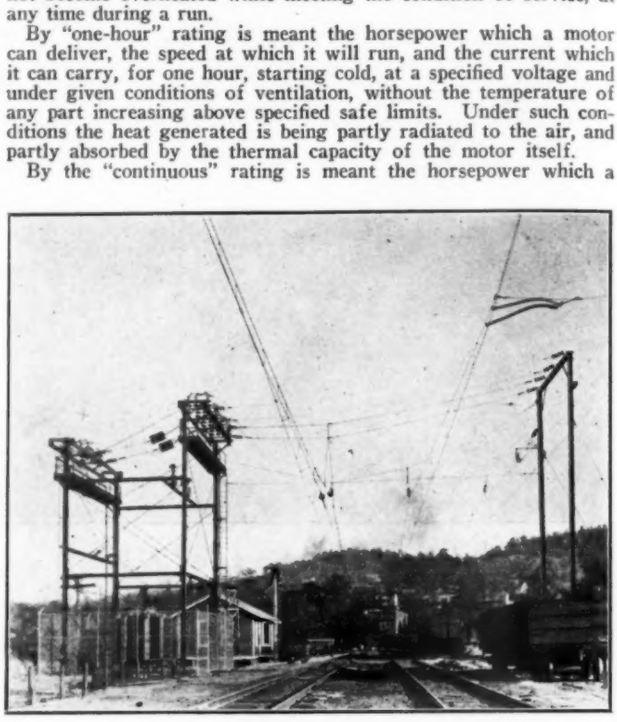
Most electrical equipment, a motor for example, involves a large mass of material which has considerable thermal capacity. If it starts cool, considerable heat may be absorbed in addition to that radiated off, before excessive temperatures are reached. This fact is taken advantage of to allow equipment to carry loads for limited times above that which it could carry continuously. Thus a cool motor may be safely overloaded to perhaps double its continuous rating for a few minutes while starting a train, but after the safe operating temperature has been reached, the load must be decreased so that heat will not be generated faster than it is radiated. Otherwise the temperature will continue to rise above a safe point. Forced ventilation is often used to assist the cooling process.

Two ratings for electrical equipment are ordinarily used; the "normal" or "one-hour" rating, and the "continuous" rating. These are useful for comparative purposes but much additional information as to the rates of heating with other loads is necessary for proper understanding of motor performance, since road conditions are frequently such that a locomotive does not carry continuously or even for an hour, any fixed load. Each individual application must be analyzed as to tonnage, length and per cent of grade, speed, etc., and equipment selected which will not become overheated while meeting the condition of service, at any time during a run.

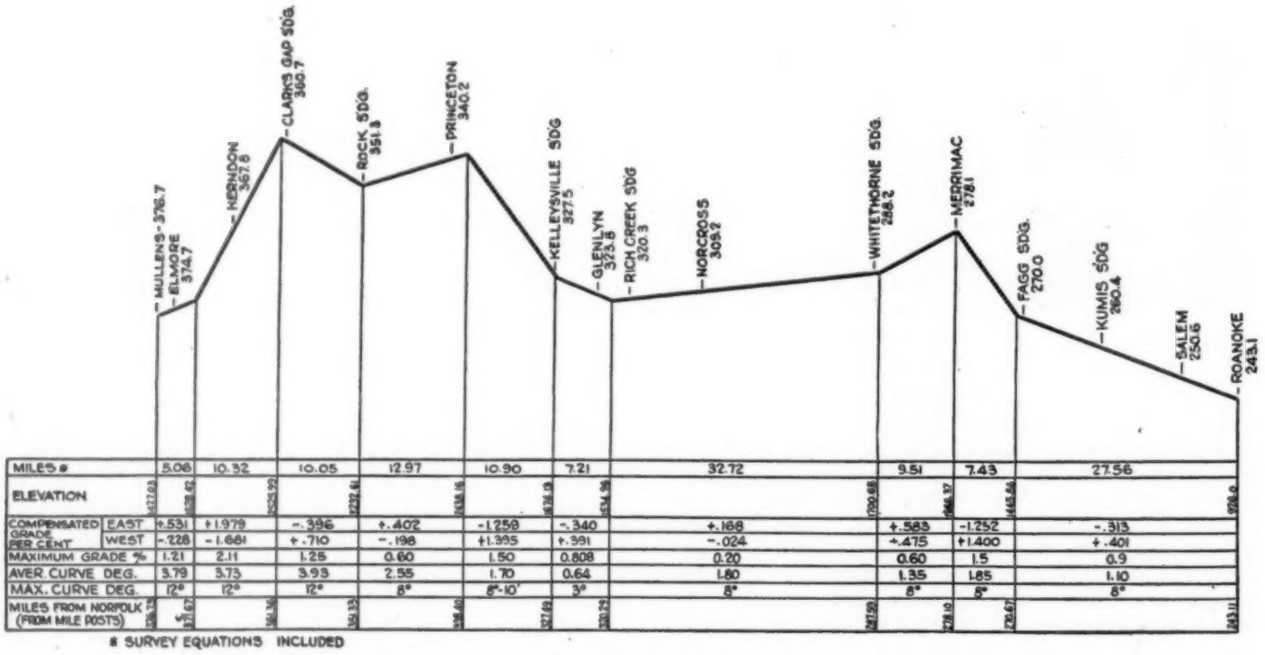
By "one-hour" rating is meant the horsepower which a motor can deliver, the speed at which it will run, and the current which it can carry, for one hour, starting cold, at a specified voltage and under given conditions of ventilation, without the temperature of any part increasing above specified safe limits. Under such conditions the heat generated is being partly radiated to the air, and partly absorbed by the thermal capacity of the motor itself.

By the "continuous" rating is meant the horsepower which a motor can deliver, the speed at which it will run, and the current which it can carry, continuously, at a specified voltage and under given conditions of ventilation, without the temperature of any part increasing above specified safe limits. The thermal capacity plays no part here since the motor is operated long enough to heat all parts to a temperature where the heat is being dissipated as fast as it is generated.

Control of current through control of voltage is of particular importance while starting. Since the current increases as the



Balancer Station at Rock, W. Va.



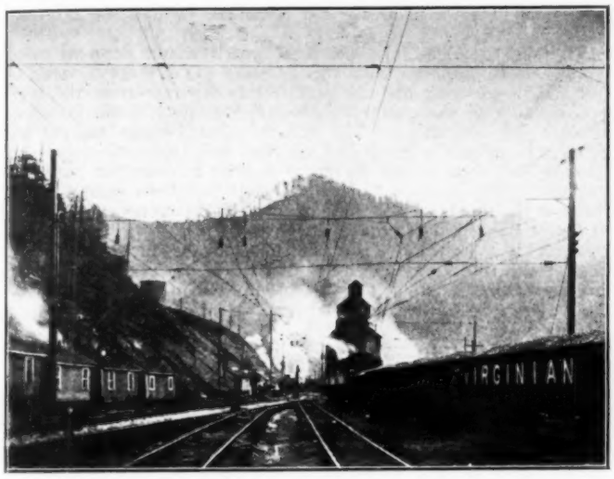
MILES #		5.06	10.32	10.05	12.97	10.90	7.21	32.72	9.51	7.43	27.56	
ELEVATION		1427.03	1532.62	1372.92	1722.61	1438.15	1474.13	1334.38	1720.58	1496.37	1445.66	998.6
COMPENSATED GRADE PER CENT.	EAST	+.531	+1.979	-.396	+.402	-1.258	-.340	+.188	+.583	-1.252	-.313	
	WEST	-.228	-1.661	+.710	-.198	+1.395	+.391	-.024	+.475	+1.400	+.401	
MAXIMUM GRADE %		1.21	2.11	1.25	0.60	1.50	0.808	0.20	0.60	1.5	0.9	
AVER. CURVE DEG.		3.79	3.73	3.93	2.55	1.70	0.64	1.80	1.35	1.85	1.10	
MAX. CURVE DEG.		12°	12°	12°	8°	8°-10'	3°	8°	8°	9°	8°	
MILES FROM NORFOLK (FROM MILE POSTS)		336.32	331.87	321.55	311.50	298.53	287.63	280.42	247.69	238.18	230.67	243.11

SURVEY EQUATIONS INCLUDED

Condensed Profile of the Virginian from Mullens, W. Va., to Roanoke, Va.

speed decreases, the current with full voltage at standstill or at low speeds would be excessive, but if the voltage can be reduced sufficiently, the current may be reduced to proper amounts. Means are therefore provided to obtain a very low voltage and consequently a safe current, at start. As the speed increases, the current decreases. The voltage is then increased slightly to again increase the current, and the process repeated until the motors are operating on full voltage. During a start, the heating up is very rapid, and the heavy starting currents should not be maintained longer than necessary. This condition is somewhat analogous to a steam engine making a heavy start where long cutoff is required, and steam is used for a short time at a higher rate than the boiler can supply it continuously. It is a case of keeping the steam locomotive "hot" and the electric locomotive "cool."

As a train increases its speed, the current in the motors, and consequently the tractive force will decrease until it is just sufficient to maintain the speed of the train. If a train is running at this "balancing speed" on the level and starts up a grade, it will slow down. As it slows down the current and the tractive force will increase, to a point sufficient to maintain some lower speed. This is similar to a steam locomotive slowing down on a grade, and running only as fast as the boiler will make steam, but here



East End of the Elmore Yard

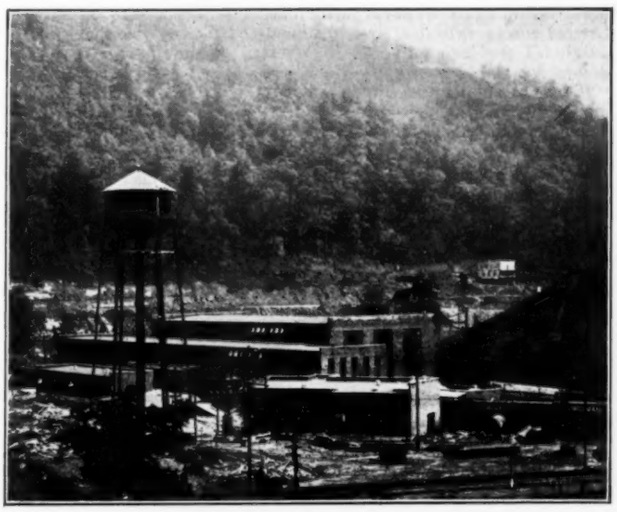
there is an important difference between steam and electric operation. The steam locomotive can maintain a high tractive power at low speed continuously (except for dirty fires, etc.) but the electric locomotive is heating up rapidly if the grade is severe or the train is heavy, and must be allowed to maintain high currents for too long a time. This condition may also obtain on level track if too heavy a train is handled. The electric locomotive will exert sufficient tractive force to "pull whatever she'll start," but it may require high currents and, therefore, will result in excessive heating.

Consequently, as mentioned above, an electric locomotive must be properly proportioned to meet the requirements of the service, safe tonnage limits must be set, and then these limits must be enforced, even though the locomotive seems able to handle heavier trains.

The above description of the operating characteristics of electric locomotives applies to locomotives with "series commutating" motors. There are in service also a considerable number of locomotives having "induction" type motors. All of the thoughts regarding the heating up of equipment, and protection therefrom, applies equally well to this type. Their operating characteristics, as compared to those of steam locomotives, differ materially however. While the "series commutating" type is a variable speed motor, which adjusts itself to different tractive load conditions by varying its speed, the "induction" motor is essentially a constant speed machine. That is, it varies its tractive force with almost no change of speed. A decrease in speed of perhaps half a mile an hour from "Synchronous" speed will run the load on the motors from almost nothing up to full load; and an increase in speed of the same amount, as on a down grade, will also increase the motor load to maximum, but in the reverse direction, since the locomotive is holding back the train when the motors are forced above their "Synchronous" speed. Thus the electrical equipment is being heated up whether the locomotive is pulling or breaking, and very small changes in speed make large changes in tractive force, current, and rate of heating.

Induction type locomotives usually have two running speeds at which they can be operated. When starting a train, and until one of the running speeds is reached, a resistance, usually of the water rheostat type, is used to control the current. During starts, by proper operation of the controller, the current may be maintained nearly constant, thereby maintaining a constant tractive force. After a running speed is reached, and the rheostat is no longer in service, the current and tractive force depend entirely on conditions of grade, curvature, tonnage, etc.

To sum up the whole matter, a "series commutating" electric locomotive has a tractive force speed curve nearly like a steam locomotive; an "induction" type locomotive has a tractive force-speed curve that is nearly a straight line at one or two constant speeds; either one will, if overloaded, become overheated; and

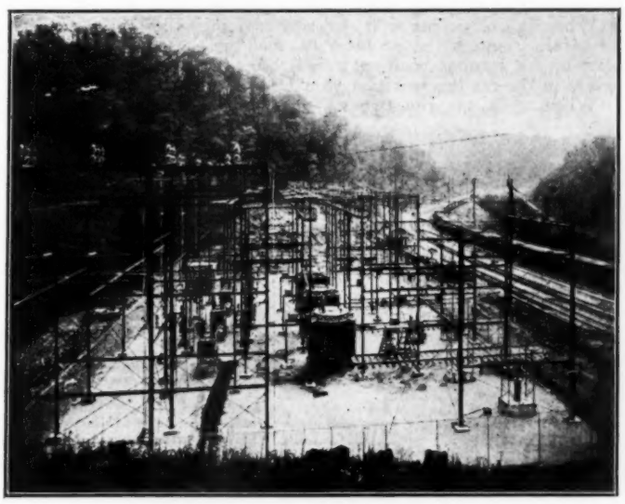


General View of the Mullens Shop

if overheated will eventually have failures of electrical equipment which will be very expensive. Therefore, first, select a suitable locomotive, and, second, see that overloading is not permitted.

Probable Effect of Height of Center of Gravity

The effect of the height of the center of gravity in a locomotive has resulted in more or less conflict of opinion, and while in steam locomotive design there is little opportunity for variation in this respect, the range is considerably wider in the case of the



Substation at Clark's Gap, W. Va.

electric locomotives, and in view of this, your committee feels that a study of the subject should prove valuable in order to determine the feasibility and practicability of taking advantage so far as possible, of designing electric locomotives with the height of center of gravity at the most advantageous point.

The advantages that may be expected to accrue from the properly located center of gravity involves from an operating stand-

point, safety and maintenance. Probably, safety enters into the question only at certain critical speeds.

From a maintenance standpoint, we have considerations of rail and flange wear, the effect on development of hot boxes, the wear and over-heating of hub liners and dangerous stresses on frames.

The committee is approaching this subject from two angles, namely, from a theoretical standpoint and from an application standpoint, based on existing practice.

In analyzing the problem from a theoretical standpoint, rail stresses will be analyzed, the center of gravity in various types of locomotives carefully determined, and lateral forces imposed upon the rails as well as the engine frames will be determined under static conditions on curves with maximum depression of springs. Lateral forces will also be determined considering the spring borne weight of the locomotive as an inverted pendulum free to vibrate within certain limits.

From an application standpoint, data will be accumulated showing the actual flange wear, wear on hub liners, number of hot boxes per thousand miles, frame failures and other data which can be attributed to high center of gravity.

It is hoped that from the data accumulated, together with the theoretical analysis outlined above, that definite recommendations can be made. The committee does not attempt to lay down any rules as to design of new locomotives, as it is felt that it would be outside of its province.

A Study of Variable Resistance Trucks With Special Reference to Electric Locomotives

The use of lateral motion trucks, constructed along the lines of what has for years been in use as a leading truck on steam locomotive does not seem to be so well adapted to the electric locomotives where cabs or units making up a locomotive are required to run in either direction. The conventional leading truck use for steam locomotives fulfills a definite function in the guiding, taking up lateral resistance, while the truck in the trailing position is required to perform a somewhat different duty, and therefore the resisting value should apparently for the best results be adjusted accordingly.

There is also a further complication of this problem in the multiple unit electric locomotives, either two or more, coupled together. The problem would seem to be further complicated in the multiple units coupled depending upon whether the locomotives are pushing or pulling. Obviously, a certain amount of lateral resistance in the leading truck of a single unit, whether steam or electrical is desirable and necessary, as it provides a force for turning of the locomotive on its rigid wheel base, helping to overcome the necessary movement and slipping of the wheels on the rail for their relative adjustment in the movement of translation. It would seem to be equally clear that under somewhat similar conditions lateral resistance in the trailing truck would be a disadvantage, affecting probably as it would the resistance to this motion or readjustment of wheels on rails.

Where a unit is run first one way and then the other, it would therefore suggest the problem of making the truck flexible so that in the leading position it will offer the requisite resistance, while in the trailing position would also be flexible.

When units are run two coupled together pulling, the condition between the units, or the condition set up at the forward end of the second unit is about the same as the single unit rounding a curve, and for the reason that the force transmitted through the draw-bar from the first unit to the second unit has the effect of lowering the reaction of the front truck, second unit, against the outside rail. When pushing, the force of the second unit through the draw-bar to the unit ahead has the effect of its following the tangent, which demands additional resistance in its leading truck; concurrently, pressure is increasing against the outside rail, which may be affected by the resistance in the rear truck of the unit in advance,—at the same time what is developing between the units may be assisting in turning the forward end of the first unit with some decrease in pressure against the rail at the forward end of the front or leading unit.

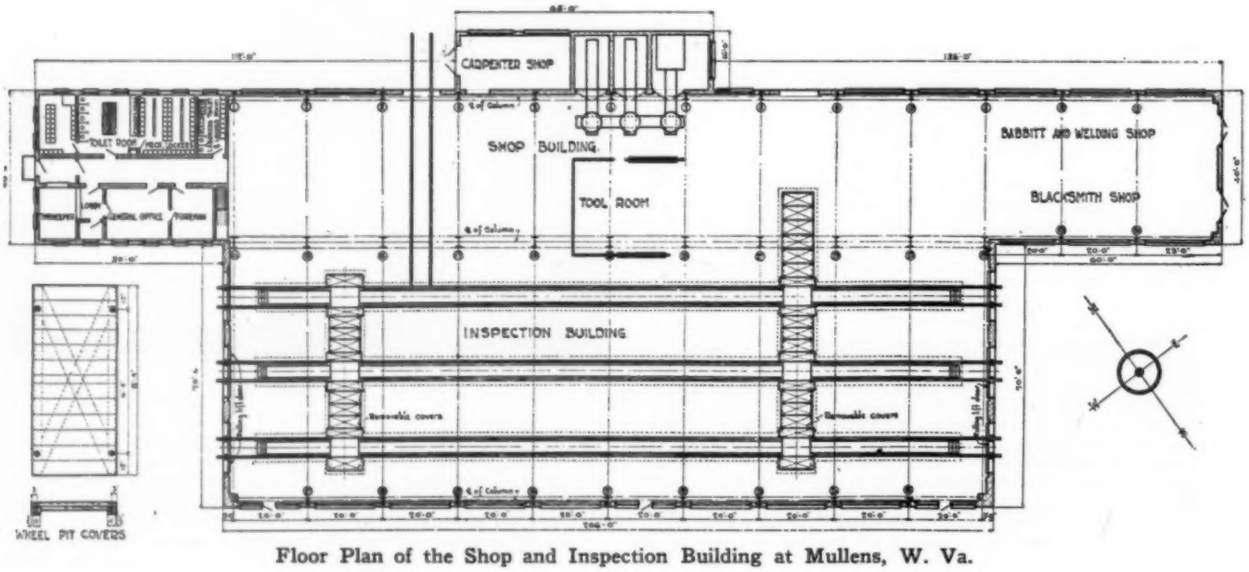
This same problem holds good in connection with a third unit and its effect on the second or middle unit when three units are coupled together; but since the second unit would also be behind the first, this force would again be magnified. This magnification of the forces, due to a further multiplication of the number of units, with increased power of the locomotive, would also make the third unit, when pulling, more easily turned. The problem is further complicated by the apparent desirability of getting trucks which will automatically set up the requisite assistance in one direction and will resist when going in the opposite direction,—and it is these effects and combinations that the sub-committee is endeavoring to solve.

All these problems are questions which would seem to affect and go hand in hand with the question of stresses as well as rail and flange wear and are not entirely separate from the question relating to the center of gravity, a subject in the hands of another sub-committee. The sub-committee states that it has given this subject a good deal of time and study, though it apparently has been unable so far to present anything of particular interest. This brief summary of what has been mainly going through the minds of the sub-committee is mentioned with a view of better illustrating to those who may be in position to assist the committee to see what it is trying to do in response to the handling of the subject assigned them in the hope that with a better general conception of its task, that other members of the Association may be better able to give the sub-committee assistance during the ensuing year.

The Virginian Electrification

The Mullens-Princeton section of the Virginian electrification is now in operation, and work on the remaining section is progressing and should be in service the latter part of this year. When the entire line from Mullens to Roanoke is complete, the electrification will comprise 133 miles of route and 232 miles of track. The part which is now in operation includes the Clark's Gap Hill, which has always caused the most severe operating difficulties on the road.

The electrification, which employs the 11,000-volt alternating current distribution system, was designed to handle twelve and one-half million tons of coal east from Elmore annually. This tonnage was set as the basis of the system layout after a careful consideration of traffic growth and the capacity of the mines served by the road. This annual tonnage is somewhat greater than that at the present carried, and while the capacity of the power plant



Floor Plan of the Shop and Inspection Building at Mullens, W. Va.

and distribution system was based on 12,500,000 tons per year, the number of locomotives initially ordered was based on an annual tonnage of eight million.

System of Electrification

As stated, the high voltage, alternating current system of electrification was selected after a careful consideration of all available systems. A power plant owned and operated by the railway, is located at Narrows, Virginia, which is 74 miles west of Roanoke and 59 miles east of Mullens. This plant contains four 12,500 Kv.-a. 25-cycle single phase turbo-generators. There are five water tube boilers with provision for a sixth, each rated at 1521 b. h. p. These boilers burn pulverized coal, which is found to be admirably adapted to following the rapidly fluctuating loads. During the operation of the Mullens-Princeton section, it frequently happens that a tonnage train accelerates on Clark's Gap Hill with no other trains in operation. This imposes a load of 18,000 to 20,000 Kv.-a. on the plant. Sudden peak loads as high as 34,000 Kv.-a. have occurred and the steam pressure has been successfully maintained by the pulverized fuel control system. It is expected that the load factor will be considerably improved after the complete electrification is in operation.

From the generators, which are rated at 9,800 volts, the power passes through four 10,000 Kv.-a., oil insulated water cooled transformers. These increase the pressure to 88,000 volts, and their high voltage sides are connected to a 88,000 volt bus, from which are fed two transmission lines, running east and west from the plant. Normally alternate substations are fed from each transmission line, but either line has sufficient capacity to handle the entire load should the other line become disabled. The so-called three-wire system of distribution has been employed. At the main transformer stations are located three-coil transformers which receive their power from the 88 kilovolt lines. The secondaries of these transformers are built in two parts, one of which feeds the trolley at 11,000 volts above the ground, and the other part feeds the feeder or balance wire at 22,000 volts above ground. The common terminal of the secondary windings is connected to the rail circuit. The potential between the trolley and balance wires is thus 33,000 volts. Between the main transformer stations are placed balancer stations containing auto transformers. These are connected between the feeder and trolley wires, with a point in the winding corresponding to one-third of the potential between trolley and feeder connected to the rail. A schematic diagram of the distribution system is attached as Figure "B." The locations and capacities of the substations are as follows:

	Miles from Roanoke	Main or Balancer	Capacity Kv.-a.
Roanoke	0	Bal.	10000
Wabun	13.3	Main	9000
Fagg	27.2	Bal.	5000
Merrimac	35.1	Main	6000
Whitethorne	44.4	Bal.	10000
Eggleston	54.9	Main	6000
Norcross	65.9	Bal.	10000
Narrows	73.8	Main	7500
Kelleysville	84.4	Bal.	5000
Princeton	97.8	Main	6000
Rock	108.2	Bal.	5000
Clark's Gap	117.4	Main	9000
Herndon	124.5	Bal.	15000
Elmore	130.9	Main	9000

The capacities of the stations given above are based on the high voltage ratings of the transformers; that is on the total Kv.-a. capacities of the units. Either the trolley rail or feeder rail winding considered alone has a smaller rating.

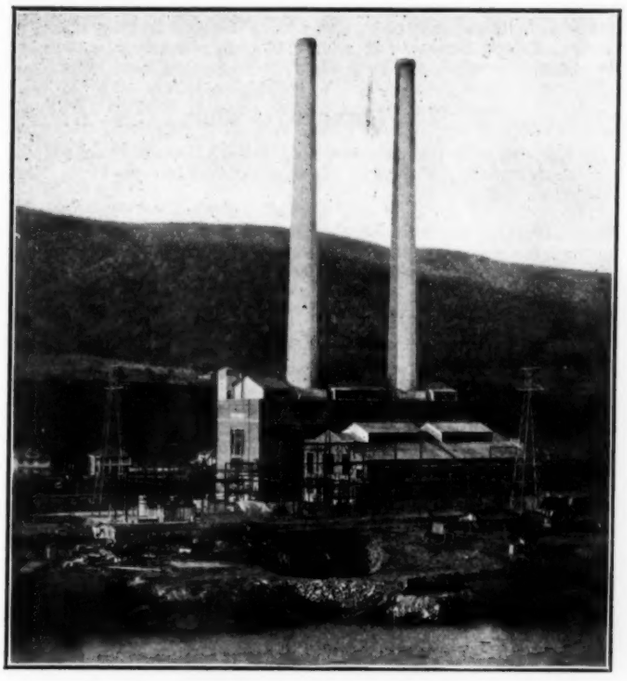
The overhead system employed has many interesting features. An H-section, structural steel pole is used, with bracket arm supports on single track sections and span supports on double track sections. The balance wire is carried on the trolley poles at all points, but the transmission lines are run across country on independent towers except in a few places. This has resulted in a considerable saving in the length of the transmission line. Because of the heavy power demands on Clark's Gap Hill, it was necessary to provide a rather large conductivity in the trolley wires. This has been provided in the form of three wires, the contact wire and two auxiliary wires all in a vertical plane, having a total copper equivalent millage of 672,720 circular mills.

Locomotives

The locomotives consist of three motive power units semi-permanently coupled together. All units are identical, but the coupling arrangements between units are such as to require shop work to separate them should this become necessary for interchanging. A total of 36 units was ordered, based on the traffic requirements of 8 million tons of coal. Of these 36 units, thirty have been supplied as ten 3-unit road locomotives, and six as single-unit locomotives to be used for local service, etc. A control stand is located in one end of each unit, the units in the locomotives being so placed as to provide control in either end of the three-unit locomotives.

These locomotives are of the split phase type, a type which has been in successful operation on other railroads for several years. The driving motors, of which there are two on each unit, are of the 3-phase induction type, the windings being arranged to give either 4 or 8 poles corresponding to two approximately constant running speeds of 28 and 14 miles per hour.

Power is collected from the 11,000 volt contact wire by the pantographs, of which there are three per locomotive or one per motive power unit. The single unit locomotives have two pantographs and normally a locomotive is not operated with less than two pantographs in contact with the wire. Power passes from the pantograph into a high tension bus line mounted on the roof and extending the entire length of the locomotive. From this bus line, connection is made in each cab, through an oil circuit breaker, to the high tension winding of the main transformer. All



The Narrows Power Plant

apparatus in the locomotive receives power from the secondary of the main transformer at a comparatively low voltage. The transformer is oil insulated and the high voltage is arranged for connection for 22,000 volts, as are also the substation transformers, when future traffic demands require the higher operating potential on the contact wire. Cooling of the transformer is effected by circulating the oil through a separate radiator. The radiator removes heat from the oil by means of an air blast from a motor driven blower. The motor which drives the blower also drives the centrifugal pump which circulates the oil.

Acceleration of the locomotive is by means of variation of the resistance of the rotor circuits of the traction motors. A liquid rheostat is used for this purpose.

The ratings, principal dimensions, weights, etc., of the three-unit locomotives are as follows:

Total weight of locomotive	1,285,160 lb.
Classification of wheels, each unit	2—8—2
Weight on drivers, each unit	315,100 lbs.
Tractive effort at continuous rating complete locomotive	8 pole 135,000 lb.
	4 pole 78,750 lb.
Speed at continuous rating	8 pole 14.2 m.p.h.
	4 pole 28.4 m.p.h.
Maximum starting tractive effort, complete locomotive	277,500 lb.
Maximum safe speed	35 m.p.h.
Rigid wheel base	16 ft. 6 in.
Total wheel base, one unit	37 ft. 6 in.
Length over all, one unit	50 ft. 9 in.
Width over all	11 ft. ¾ in.
Height from rail to locked position of pantograph	16 ft. 0 in.
Diameter of driving wheels	62 in.
Diameter of truck wheels	33 in.
Gear ratio	21:100

The mechanical parts of these locomotives were designed with a view to keeping the structure so rigid in all directions to enable it to withstand any and all usual service and maintenance conditions. Tieing the locomotive frames together for the full length between the two motors is a continuous casting upon which is mounted

most of the heavy equipment in the cab. . This method of supporting the heavy electrical equipment reduces to a minimum any tendency of weaving between frames which in turn would result in objectionable effects upon the relatively more vulnerable electrical machinery.

This backbone casting also serves to add a very large amount of stiffness to the entire structure in a vertical plane.

The cab is rigidly mounted upon brackets attached to the backbone and depends upon the flexibility in the equalization for cushioning to the rail.

The guiding truck, while it follows well developed principles of design, is unusual in one respect; namely, that two restraint elements are used. These elements, the swing link and the cam rocker, are so arranged that the lateral guiding force increases proportional to the swing up to a limiting value and beyond this swing the truck functions as a constant resistance one. The main advantage of this arrangement lies in the fact that the trailing truck with its reduced swing imposes a less severe duty upon the leading driver flange than would be the case with a constant resistance truck.

The Locomotive Shop

In keeping with the complete program of electrification adopted by the Virginian, a modern electric locomotive shop has been erected at Mullens, W. Va.

The design of the shop was worked out jointly by the electrical manufacturers, the consulting engineers, and the railway. Locomotives are given a light inspection at the outdoor inspection pit. Modern standing equipment has been erected near the shop, and provision is also made at this point for flushing and replenishing the electrolyte of the liquid rheostats. Heavy overhaul work is done in the main bay. A complete equipment of machine tools has been installed for machine work on the locomotive parts, and the entire floor space is served by overhead cranes. Drop pits are provided at both end of the main bay, equipped with hydropneumatic jacks of ample capacity for lifting a truck or any pair of drivers under load.

Direct current power for the cranes and machine tools is supplied from a motor generator substation near the shop. This substation contains two 200-k.w., 250-volt direct current generators each driven by a direct connected 295-h.p., 440-volt, single phase, synchronous motor. These sets receive power through transformers supplied from the trolley rail circuit from the Elmore substation. Single phase, 25-cycle alternating current power at either 220 or 440 volts is also available in the shop.

Preparation for Electric Operation

Every effort was made to have the beginning of electric operation cause the least possible trouble and interference with the operation of the railroad. A carefully studied program of instruction and training was adopted. The beginning of this program was the sending of two locomotive engineers, one electrical foreman and four mechanical foremen, chosen from our steam operating organization, to the manufacturer's plant during the time that the locomotives were being constructed. These men spent several months with the manufacturer's engineers, studying under schedules and regular instructions the construction and operation of the locomotives and becoming familiar with the main and control circuits. An instruction book was prepared for the use of the enginemen and this was used as a basis of the training. The fact that only one of these men had had previous electrical experience, and the ability which they have since shown in handling the engines and in locating troubles is proof of the soundness of the plan and the diligence with which they undertook their responsibility at the manufacturer's plant.

With the co-operation of the engineers of the electrical manufacturer, we have been able, with the aid of our men, who were trained as above, to teach the enginemen and shopmen properly to operate and maintain the locomotives. Prior to regular operation a section of track was set aside at Princeton for instruction purposes. A box car was fitted up with benches, blackboards, etc., and when the first locomotive arrived in July, 1925, actual instruction of enginemen began. Each man was given an instruction book and the circuits and operation were first studied in class and then the parts explained and demonstrated on the locomotive. Great stress was laid on a knowledge of the control circuits and locating and correcting ordinary control derangement. This knowledge was made a minimum requirement before men were permitted to operate locomotives with an instructor.

Actual operation of trains on Clark's Gap Hill began September 15, 1925, and after this time instruction work was transferred to Mullens. Methods of instruction were similar except that the added advantage of observing the operation of tonnage trains was available. At the completion of his course of instruction, each man is required to take an examination.

The instruction of enginemen does not stop with their completion of the prescribed course of instruction. The road foreman of engines is constantly on the road, riding the locomotives and instructing the enginemen in the operation of the locomotives and the handling of the trains. Trains of the tonnage handled by the Virginian have not previously been handled electrically on any railroad, and considerable care and judgment must be exercised by the operators, especially at certain points on the profile.

Operation of the Electrified Zone

Most of the coal handled by the Virginian comes from mines west of Mullens on the main line and on the Winding Gulf Branch. This coal is brought into Elmore Yard by steam locomotives and there trains of 6,000 gross tons are made up. A single road locomotive pulls the train out of the yard, the pusher is then coupled on. The double train then ascends the grade to Clark's Gap, a distance of 14 miles, with an average grade of 2.0 per cent, the time required being approximately 58 minutes. The locomotives run at constant speed regardless of the grade, the speed being considerably greater than that at which steam trains were formerly operated.

Sufficient tracks are available at Clark's Gap to provide facilities for filling out trains to 9,000 tons at that point. The 9,000-ton trains are now being handled to Princeton by one locomotive and will be continued to Roanoke with the same locomotive when the electrification is completed. The weight of a corresponding westbound train of empties is approximately 2,800 tons. Hill crews are operated between Elmore and Clark's Gap, one hill train taking up sufficient tonnage to fill out two eastbound trains.

All locomotives are inherently regenerative and all trains are held going down grade by regenerations without the use of air brakes except for bringing the train to a stop. If other trains are drawing power while a train is regenerating, the regenerated power is absorbed by these trains. In case no trains are drawing positive power from the distributing system, the power returns to the power house and, if it exceeds that necessary to supply the power plant auxiliaries, a regenerative rheostat is brought into action and the excess power absorbed in that way.

As stated above, the power house and distribution system were laid out on a basis of 12½ million tons of coal per year, while the number of locomotives initially ordered was based on 8 million tons of coal. The amount of equipment and its capacity depend not on the total annual load but on the peak load or on the maximum day. On roads like the Virginian the maximum day is usually very much in excess of the average day. The amount of this excess was set at 60 per cent before the electrification was laid out, this figure being based on operating experience. The heaviest day so far experienced under electric operation occurred on Nov. 22, 1925, when 10 tonnage trains were operated over Clark's Gap Hill. This represented a movement of 56,580 gross tons, or 1,530,120 ton miles in 19 hours. Six electric locomotives, with a total weight of 3,855 tons, were required for this movement, resulting in 307 ton miles being handled per ton weight of electric motive power.

The heaviest movement previous to the electrification occurred on June 14, 1924, when 60,155 gross tons were handled over Clark's Gap Hill by 20 large Mallet engines, representing a total weight of 7,952 tons, including tenders. This represented a movement of 2,075,350 ton miles, or 261 ton miles per ton weight of steam motive power used.

This is not intended to be an argument for electrification, for, of course, many other things than motive power alone must be considered in making an equitable comparison, but it does show that much more can be accomplished with electric locomotives than with an equal weight of steam power.

Complete operating costs will not be available until some time after the electrification to Roanoke has been in operation. The Virginian, however, feel that present results indicate the success of the undertaking.

The Design of Multiple Unit and Trailer Cars for Terminal Service of Trunk Line Railroads

1. The demand for rapid and frequent transportation to and from our larger cities has introduced a serious problem for all transportation agencies, including trunk line railways whose tracks are so located as to make them available for use to commuters. The expanding suburban population has made necessary this rapid and frequent service. In order to reach the centers of large cities, underground lines are often necessary. Transportation under these conditions is best handled by electric multiple unit cars.

The advantages of a home in the suburbs satisfy a large number of people to the extent that they are willing to ride as long as an hour to work in the morning and home again at night. The fact that all start and stop work at about the same hours, results in a decided traffic peak load at these hours far above the daily average load. In many cases, the maximum of terminal and carrying capacity is rapidly being approached. Since the design of the multiple unit cars used effects very materially the capacity of a terminal, every improvement afforded by most recent develop-

ments should be utilized in their design. It is the purpose of this paper to bring to attention the developments found most useful in service.

In deciding on the type of equipment best suited for any given terminal, the following items must be carefully investigated:

I. All cars motor cars versus motor cars and trailers; or ratio between motor cars and trailers.
II. Car passenger carrying capacity.
III. Weight.
IV. Schedule speed.
V. Details of body and truck design.

Motor Cars vs. Motor and Trailer Cars

A multiple unit train of a given number of cars can be made up of all motor cars, or of motor cars and trailers split on a predetermined ratio in accord with the electric motor size. In special cases, cars running on both alternating and direct current can be best built with respect to first cost, minimum weight, and efficiency by using four motors per motor car, and trailers. In common cases, all service requirements can be met and cheap first cost obtained by using two motors per motor car mounted on one truck and trailers used in small proportion. Switching movements in making up trains are easier where all are motor cars. In some instances, it is desirable to have every trailer equipped with control apparatus so the train can be made up easily. On some railroads trailers are not equipped. Where trains are seldom changed in make up it is possible to save on first cost by the elimination of control locations and yet not make switching operations involved.

Passenger Carrying Capacity

Car capacity may be varied considerably depending on the character of the service. The openings for admission and discharge of passengers must be in relation to the speed with which passengers have to be handled and cars may be designed of body length varying between 50 ft. and 70 ft. providing the openings for entrances and exits for passengers are suitably arranged. If long bodies and center doors are used, car floor level station platforms are involved. The relation between seating capacity, standing room and arrangement of openings depends on the character of the service. By arranging the inside dimensions of the car to a maximum, a seating arrangement with three passengers on one side and two on the other has, where the service is suitable for it, met with considerable success in increasing car capacity. In classes of service where it is desirable so far as possible that all passengers shall be seated, the space provided per seated passenger should not be less than a well defined minimum. It is important to leave as wide an aisle as possible consistent with adequate width of seats. On trunk line railroads handling suburban business, minimum toilet facilities should be provided. This can be accomplished by one toilet per car or per motor car only. However, health regulations may modify this.

Where loading is heavy, to interfere the least possible with the rapid handling of passengers, all doors should be sliding. Rapid handling of doors is facilitated by electric-pneumatic operation, satisfactory devices for which are available.

The dead weight of car and equipment should be a minimum, consistent with safety, reliability, economical maintenance and maximum utilization. In general, this equipment is used for comparatively short trips, where the consideration of comfort, as required in main line service is of secondary importance. It is probable that truck weight including motors can be, by careful study, materially reduced and also that air brake and body parts may be reduced by careful selection of materials and design below that now common. The minimum weight to which design, as indicated above, may be reduced cannot now be accurately predicted. An average figure based on existing practice would be 1,000 lbs. to 1,500 lbs. total weight of car per seated passenger. These comparisons, however, do not mean very much because due consideration must be given to the standing room allowed as well as to the number of passengers seated per car and also because the weight of motor cars will vary with the system of electrification used.

While power requirements should not dictate the weight limits of the car, they nevertheless should not be ignored. It should be borne in mind that there is a saving in accelerating power requirements and in the energy dissipated through braking from a reduction in the weight of the car.

Speed

A means of increasing track and terminal capacity to cope with peak demands is high traffic density, which can be produced by high speed, traffic density being defined in car miles per track mile per hour. Multiple unit cars can be designed to give a greater traffic density than any other type of equipment and reaches its maximum utility for intensive service during peaks.

Where schedules are fast and stops frequent, cars must have ample capacity to permit very rapid acceleration. Electrical equipment may be selected with capacity to accelerate at any speed within reasonable limits and to maintain this speed for any periods that are desired.

Equally important with high accelerating rates are high braking rates. The latest types of air brake valves and foundation brake rigging permit very high braking rates with safety and smoothness of operation. Electro-pneumatic brake equipment contributes to rapid and smooth deceleration.

Body and Truck Design

One of the most important requirements to be met in the design of this class of equipment is reliability. Traffic conditions require that trains be operated with a minimum of headway during peak hours. Therefore, a delay to a train or its inability to adhere to schedule will likely result in a very embarrassing delay to other trains or even a tie-up of traffic and inconvenience to a very large number of passengers. While there are many other features involved in the design of equipment for terminal service, reliability must ever be uppermost in mind. Reliability can be obtained by simplicity of design, ruggedness of parts and good material and workmanship.

For the type of service under consideration, only steel underframe steel body or equivalent with vestibule ends should be used. This for maximum protection in case of fire or accident. A car of recent design embodying these features in simple form is the so-called "Covered Wagon Type."

The cars must be well heated, lighted, ventilated, and equipped with good seats. Where possible, arm rests are desirable, also provision for smokers. When heaters are located under seats they should be so arranged that they do not make the seat undesirably hot. Lighting should comply with recommendations made in reports on best practice.

Particular attention should be paid to easy riding and quiet cars because it is possible to obtain these without weight or other physical limitations by use of flexible gears, spring supported parts, well developed motor control transitions, proper draft gear and buffers, limitation of overhang, side bearings and proper wheel size.

During rush hours cars in this service are often loaded beyond their seating capacity, hence the necessity for special attention to ventilation.

The heating arrangements will, of course, depend upon geographical location and climatic conditions.

Multiple unit equipment will, in general, have to be heated electrically with due regard to heat control, which may be taken care of automatically.

In most instances, equipment of this character will occasionally have to be used in conjunction with standard main line cars. It is, therefore, essential that the draft rigging be so designed as to introduce no difficulties on this account.

Manual coupling of electric circuits is generally in use although there are some automatic devices in use which require special types of draft gear.

To keep the equipment involved in handling the service to a minimum, all features of the equipment must be accessible for repairs and must be arranged to fit in with the shop facilities best suited. An ample supply of repair parts and design of equipment so that unit parts may be replaced without the withdrawal of the car from service is desirable. In special cases, spare trucks may be utilized to advantage.

Trailer Cars

Whether or not trailer cars can be used to advantage depends largely on conditions surrounding each project. In some cases, the practice has been found unsatisfactory on account of causing congestion at outlying points coupled with the lack of flexibility in handling. In other cases, their use is proving desirable and economical. The division between motors and trailers may also be influenced by the kind of installation used as explained earlier in this report.

In general the trailer car body size and arrangement may well be a duplicate of the motor cars. This will have a tendency toward standardization, hence reduced stock, and simplification of repairs. The same design and layout consideration apply to trailer cars as to motor cars. It is felt that uniform strength of essential members should be provided in all cars in a train whether motors or trailers.

The trucks may be lighter, however, since they are not called upon to transmit the propelling force. There would seem to be no reason to make them heavier than required by considerations of strength and safety. There, of course, may be cases where, for sake of uniformity, it is desirable to use the same trucks under both types of cars, but such cases will undoubtedly be of a special nature.

In considering the subject of passenger equipment for terminal service, it is believed timely to make mention of articulated trains.

Steam operated articulated trains have met with some degree of favor in England and on the Continent. The committee desires to invite your attention to the report of the Heavy Electric Traction Committee, American Electric Railway Association for the year 1924, in which the subject is quite thoroughly covered.

Owing to the limited amount of such equipment in service in this country, it is not possible to draw reliable conclusions at this time. However, assuming that designs are possible that will prove satisfactory in operation, there are certain advantages worthy of consideration. The articulated train may lend itself to unusual applications. By virtue of the reduction in number of trucks, there is a possibility of lesser mantenance costs that should be in direct proportion to the reduction in parts. A tendency should also be present toward a lessening of noise.

The most serious disadvantage evident is the loss in flexibility with which equipment may be used. All cars that are coupled by means of the articulated connection form a unit which cannot be readily broken up to meet varying conditions of traffic. Where the variation is great, this disadvantage may assume such proportions as to more than offset such advantages as appear to exist in other directions. The developments along this line are being watched with considerable interest with a view of making such recommendations from time to time as seem pertinent.

Electrification Progress

Domestic

During the fiscal year just ending there has been comparatively little electrified mileage added to that contracted for and under construction as shown in the 1925 report of the Committee. The few cases to be chronicled may be listed as follows:

First. The Great Northern 24 mile electrification which also includes the original four mile Cascade Terminal project installed in 1909. It is of interest to note that it has been found desirable to abandon the existing type of installation and adopt the motor-generator type of locomotive. Provision is to be made, however, so that the existing three phase locomotives may be operated from the single phase trolley to be used under the new plan.

Second. The Pennsylvania Railroad is undertaking the electrification of a part of its Southern Division from Philadelphia to Wilmington, a distance of approximately 26 miles.

During the period covered by this report several projects were completed wholly or in part and put in operation. Others are still under construction.

The Virginian Railway now has a section of its main line under electrical operation and a description is included as a part of this report, being Exhibit No. 5.

The New York, New Haven and Hartford Railway inaugurated electrical operation on that portion of its New York Division between South Norwalk, Conn., to Danbury, Conn. This is a single track line of approximately 25 miles.

The Staten Island Rapid Transit Railway, a subsidiary of the B. & O. Railway, inaugurated electrical operation on that portion of its line from the St. George Terminal to Tottenville and a branch from Clifton Junction to South Beach also from St. George along the North Shore of Staten Island. Twenty-eight miles of double track line are brought under electrical operation by this project.

The Long Island Railroad has extended the electrification of its lines to include approximately 28 miles between Jamaica and Babylon in the vicinity of New York City.

The electrification of the Chicago suburban lines of the Illinois Central Railroad is progressing rapidly and it is expected to inaugurate electrical operation over a portion of this district within the next few months.

The New York Central has contracted for ten gearless passenger locomotives similar to those now in operation. Seven switchers and two freight locomotives have been built for this road and are now on test. These are the forerunners of others that will be required for electrical operation of the West Side (New York City) freight yards, and represents the first geared type locomotives to be used on the New York Central.

Five freight and two switchers, motor-generator type locomotives for the New York, New Haven and Hartford, as referred to in last year's report, have been built and are now on test. Their operation is being watched with a great deal of interest.

The motor-generator type locomotive for the Detroit, Toledo and Ironton Railroad, also referred to in last year's report, has been completed.

An interesting development of the year of particular interest to those roads using or contemplating the use of multiple unit equipment, is a system of Regenerative Braking. This is now undergoing service tests on equipment of the Chicago Rapid Transit Company.

The development of the oil-electric locomotive is going forward with increasing impetus. A number of such units are now in service on different roads and others are under construction. Thus far this type of motive power has been confined to yard switching service but the extent of its field has not yet been determined. Designs have been made of oil electric locomotives capable of developing 1,500 h.p. but to date nothing this large has been built. Progress along this line is commanding a great amount of attention and it is hoped that sufficient operating data will soon be available that will make it possible to arrive at an average that may be expected to obtain when considered over a period of several years service.

Considerable progress has also been made toward applying the gas engine for passenger car propulsion in branch line service. Both mechanical and electrical transmission are being employed in rapidly increasing numbers and appear to be proving an economical substitute, in certain cases, for steam operation. The trend of this development seems to be toward units of sufficient power to permit the use of one or more trailers. Duplicate power units are also being used in certain cases where the profile and traffic density is such as to require more power on some parts of the run or at certain times, than is normally required.

Foreign

A great deal of activity is in evidence in foreign lands, being stimulated to a large extent with fuel costs. Both in the British Isles and in France extensive electrification programs are in process. Germany, Austria, Switzerland, Italy, Russia, and the colonies of some of these countries, are gradually adding to their electrically operated mileage.

The Southern Railway of England has underway what is purported to be the World's Greatest Suburban Electrification, comprising 647 track miles. Today less than 200 miles have been so converted, but the program is going forward quite rapidly.

The French railway scheme embodies the electrification of approximately 2,000 miles on each the Midi, Paris-Orleans and Paris-Lyon-Mediterranean. The Midi has thus far made most progress and now has in service approximately 350 miles. The initial scheme of the Paris-Orleans provides for the early conversion of approximately 312 miles, of which a considerable portion is now under construction and includes the completion of 1,000 miles by 1930. The P. L. M. scheme contemplates the immediate conversion of approximately 600 miles, largely under construction and a portion nearing completion.

The South African Railway has recently completed the electrification of 171 route miles of its heavy mineral traffic heavy grade section.

The Great Indian Peninsula Railway of India has under construction the conversion of 300 track miles between Bombay, Poona and Igatpuri. (Includes 128 miles of suburban now in service.)

The plans of the Swiss Federal Railways provide for the ultimate electrification of its entire system of 1,802 miles. Of this mileage 973 miles are to be converted by the end of 1928 or nearly all the main line.

The Swedish State Railways has had its entire line of 286 miles in process of conversion and latest reports indicate that electrical operation has started.

The Paulista Railway of Brazil is extending the electrification of its lines by 25 miles from Tates to Rio Claro.

The Mexican Railway is extending the electrification of the Maltrate incline 17 miles eastward.

Future Committee Work

Of the nine subjects suggested by the committee for its consideration during the year just ending, five were finally selected and reported upon herein. Of these five subjects, two only are completed, the remaining three being covered by progress reports. The three subjects which require further study are as follows:

1. Probable Effect of Height of Center of Gravity of Electric Locomotives.
2. A Study of Variable Resistance Trucks.
3. A Resume of the Virginian Electrification Project.

The committee requests authority for continuing the work on these subjects.

Of the nine subjects suggested last year, the following remain without having received consideration, and these are again being mentioned, as it is believed that the committee can handle one of these subjects during the ensuing year, in addition to those carried over. These subjects are as follows:

1. A Basic Outline to Govern Method of Reporting Costs and Performance with a View to Using Existing I. C. C. Reports.
2. Methods for Computing Structural Construction of Electric Locomotive Cabs.
3. Spring Rigging and Spring Gear Studies for Electric Locomotives.
4. Gear Design.

The report is signed by L. K. Sillcox, (chairman), general superintendent motive power, Chicago, Milwaukee & St. Paul

Railway; G. C. Bishop, superintendent motive power, Long Island Railroad; W. L. Bean, mechanical manager, New York, New Haven & Hartford Railroad; J. A. Carmody, superintendent electric equipment, New York Central Railroad; J. H. Davis, electrical engineer, Baltimore & Ohio Railroad; A. Kearney, superintendent motive power, Norfolk & Western Railway; J. V. B. Duer, electrical engineer, Pennsylvania System; J. W. Sasser, Superintendent motive power, Virginian Railway.

Discussion

W. B. Potter, General Electric: My early experience was with steam and I have always had and always will have a great admiration for the steam locomotive. I must admit the steam locomotive is undergoing a considerable development and if it keeps on will soon have as many attachments and auxiliary features, in fact, even more, than an electric locomotive. Carrying the steam locomotive to its ultimate will, in many cases, naturally lead to the use of electric locomotives.

I believe it is true that any railroad operator who has used electric locomotives has found them to have a greater percentage of availability, more reliability, and of greater power than it is possible to obtain with any steam locomotive that has as yet been built.

A reference has been made to keeping the steam locomotive hot and the electric locomotive cool. Incidentally there is a certain advantage in that, whereas with the steam locomotive it may be necessary to reduce the tonnage in extremely cold weather, with an electric locomotive the lower temperature permits of a greater performance. Even with the increased friction of trains that occur during the winter time, when the lubricating oil is thick and the train friction is increased, it is possible in most cases to maintain the same tonnage as in the summer.

If a locomotive for heavy main line service is equipped with motors which will permit operation of something like, say 15 to 18 per cent coefficient, there is little likelihood that that locomotive will be overloaded in operation. Fortunately, nature has provided a limit to adhesion which is really the safety valve in the performance of an electric locomotive. Probably 18 per cent average coefficient is about as high as will be found satisfactory in regular operation.

The running qualities of a locomotive are a simple problem at low speed. There is, however, a problem in developing a locomotive, either steam or electric for that matter, for very high speed operation. The question of center of gravity has been often discussed for its proper location is advantageous. If the spring mounted superstructure can roll it eases off the thrust on the bearing and on the flanges, reducing flange wear and the thrust on the track. In cooperation with the American Locomotive Company continuous tests are being carried on for different types of locomotives at high speeds.

We have a track about four and a half miles long, at Erie, which is of such a character that it is possible to operate at perhaps a maximum speed of 120 miles an hour. A test was recently made of the New York Central locomotive that was designed primarily for switching service. This locomotive which may be observed over on the exhibition track, was run at 78 miles an hour and ran very well. We hoped to operate it at the maximum speed limit, but with the voltage available that was the maximum possible. I believe that locomotive would have run all right at 85 to 90 miles an hour. I mention that as indicating that that type of truck construction—which might be considered a development of the street car—does operate very successfully at high speed.

The electric locomotives also provide something which it is not possible to obtain with steam locomotives, that is regeneration—eliminating the necessity of air brakes and the surging of trains going downgrade.

For heavy terminal service it is questionable whether locomotives will ever be found practical. Perhaps the best illustration of that is the Illinois Central terminal where they have 10-car trains weighing about 600 tons. The motor cars have four motors, and with an equal number of trailers, this means 20 motors of 250 horsepower each, making a total of 5,000 horsepower. The actual power requirement to accelerate that train will be between 5,000 and 6,000 horsepower. The tractive effort during acceleration will be approximately 90,000 lb., carried up to 25 m. p. h. or better. A locomotive of any type—steam, electric or otherwise—would have to be a very heavy machine and would add materially to the weight of the train performing a corresponding service.

I believe the articulated train has something to recommend it. I rode on the English train to which reference was made and, with all due regard to the riding qualities of passenger coaches in England, this articulated train which was made up of five units was the smoothest riding train that I have ever been on. An articulated train has one more truck for the same number of cars and it, therefore, has an advantage in reducing the weight, and to some extent also the maintenance, by reason of the less truck equipment required.

Speaking of the arrangement of the car with respect to loading and unloading, I remember one time being in the Victoria station, seeing an English train coming in and I checked the unloading. Twelve hundred passengers were on the platform in 12 seconds. Their cars are all arranged with compartments and a side door for each compartment and the time required for emptying one compartment was all the time required for emptying the entire train.

We not only have the electric locomotive now, but we have the oil-electric locomotive and also gas-electric motor cars. The gas-electric motor car was the earlier development and a number have been in operation for nearly 15 years. The result of service with those cars indicates a reliability of operation and a lower maintenance than might be expected, and that maintenance has not increased during these 15 years more than the proportional increase in general maintenance.

The exploitation of those cars has recently been more actively undertaken, and I believe as a method of transportation it probably provides the greatest return on the investment of any new form of transportation that has been introduced. I believe that the figures are about 40 cents a train mile because most of these cars haul a trailer. Compared with steam operation, this is a large return on the original investment.

The use of gasoline as fuel is very satisfactory and to some extent it has been used in locomotive service. The comparative consumption between oil and gasoline is about one to one and two-thirds, and at the present prevailing rate in the cost of fuel this would mean about five to one for a corresponding car output. Attempts are being made in gasoline cars to use a distillate or a low grade of gasoline which can probably be purchased at something like half the cost of gasoline and that will reduce the ratio.

In locomotive service, where the power requirement is considerably larger, the oil locomotive has an advantage. The oil engine, as you probably know, is the most economical type of motive power there is in the consumption of fuel. In fact, such an engine has a lower fuel consumption than the best modern steam power station that has ever been built.

The average load for something like a 15 to 20 per cent power factor is an output of perhaps 40 horsepower in a 300 horsepower engine. The power developed is better than 6 kilowatt hours per gallon of fuel.

Incidentally an oil-electric locomotive is after all only an electric locomotive carrying its own power house. If you want to operate that locomotive from a power house, it only means a third rail or overhead conductor depending on the conditions taking power from the central power station.

Two engines may be used on one locomotive. This provides for operating in a higher load factor, because when the locomotive is running light it is only necessary to run one engine, and the fuel consumption will range from that 15 per cent load factor with an efficiency of 6 kilowatt hours per gallon of fuel up to about 11 kilowatt hours per gallon of fuel.

I believe the maintenance of the oil-electric locomotive is going to be materially less than that of the steam locomotive. While it has been developed thus far only for switching service, other locomotives of about 800 horsepower are under construction for tryout in light branch line service. In switching service in nearly every case oil at 5 cents a gallon is about equal the cost of coal at $1 to $1.25 a ton. I think $1.25 is a fair price, so that if coal should cost $5 a ton, the cost of fuel with the oil-electric would be one-fourth the cost of coal. In one case where coal was $11, the difference in fuel cost was at the rate of ten to one.

The maintenance being less—probably half that of a steam locomotive; the fuel cost being a good deal less and the availability nearly double that of the switch engine, there is some measure of offset against the higher cost of the oil-electric locomotive.

If it was not for the high initial cost—which we hope in time may be reduced, although an oil engine is not a cheap machine to build—there would be no question whatever about the more general use of that type of machine. A machine has been designed with 1,500 horsepower and two of these could be operated together giving 3,000 horsepower. You can readily see that this will meet any main line service requirement.

Before the general discussion from the floor written comments from E. B. Katte (New York Central) and from George Gibbs (Pennsylvania) were read.

E. B. Katte (N. Y. C.): A few corrections should be made before the report is finally adopted. It is important that the meaning of "one hour" and "continuous" rating of motors be made clear for it is true that the average railroad man has little comprehension of this measure of power, involving as it does the elements of time and heating, with which the steam engineer is not always familiar.

The description of these ratings would be materially improved by the omission of the words "the speed at which it will run" since the words add nothing.

The tractive effort miles per hour diagram marked Fig. 1 in the report shows that the tractive effort of the steam locomotive falls off immediately as the speed increases, whereas the tractive effort of the electric locomotive is maintained constant up to a given speed. The text does not correctly state this condition. ". . . the tractive force speed curves of such locomotives are of the same general shape as those of steam locomotives, that is, they maintain a maximum tractive force limited by adhesion or otherwise up to some definite speed . . ." The diagram and the text do not agree.

In reference to Fig. 2 the report states that the maximum tractive force of an electric locomotive is obtained only at low speeds and is usually limited by adhesion or by ability of the motor to accommodate current. It is not unusual to design a road electric locomotives to maintain a tractive effort equal to 25 per cent of adhesion up to 40 or more miles per hour. Electric locomotives that do less are under-motored.

An insert table appears in the report, summarizing the statistics for recent electric locomotives. The information given for the New York Central locomotives is not entirely correct.

Mr. Carmody advises me that he did not have an opportunity to check this date before the report was published and that in so far as the New York Central locomotives are concerned the information was furnished by the manufacturer and probably reflects early designs rather than the locomotives as built. Perhaps there may be other erroneous data in the table and I suggest that a complete check be made before publication.

Would it not in the future be preferable to obtain information concerning equipment direct from the railroads rather than from the manufacturers. It is not unusual that the publicity representative of a manufacturing company is not in possession of the facts concerning equipment as actually built to the railroad specifications.

George Gibbs (Penna): The Committee lists in the report several phases of the subject which have been under consideration and I would suggest that in future reports it should deal also with the question of motor drive for electric locomotives. This is a subject which has an important bearing on the entire locomotive design, mechanical as well as electrical, and is one regarding which there exists much difference of opinion among designers. I am sure that the Division would like to have up-to-date views from the committee on this subject and an opportunity to discuss them at a future meeting. It would appear, off-hand, to be a simple thing to incorporate in the locomotive a rotating power unit to impart motion to rotating driving wheels, rather than to be obliged to change reciprocating to rotary motion as in a steam locomotive, but in practice it has been found far from an easy matter. The reciprocating connection of a steam locomotive has its weak points, as we all know, one of which is the impossibility of securing perfect balance of the reciprocating weights. The steam locomotive connection has, however, at least one good point and that is flexibility and the cushioning effect from the steam behind the piston to take up irregularities and shock and is thus an important factor in relieving strain on the connections and the locomotive frame. The electric motor of a locomotive is a powerful machine having a heavy rotating part revolving at high speed; its inertia is, therefore, great. Lack of perfect alinement in the connecting links, whether gears or rods, or both, between the rotating armature and the wheels tends to introduce uncushioned stresses as does also a sudden change in the relative velocity of moving parts, such as occur in the slipping of driving wheels on the track. The locomotive designer is, in fact, faced with a most difficult and complicated problem in adapting an electric motor to produce the great variety of requirements of a serviceable locomotive among which are economy in first cost, durability and perfect tracking characteristics; this latter, of course, involves the questions of wheel arrangement, weights and height of center of gravity.

The large amount of interesting information as to what has been done in devising different types of motor-drive for locomotives could be furnished by the committee, both for foreign as well as American practice, and I believe would be very useful to the locomotive designer as well as the railroad man in determining the direction which progress should take.

Another question which might be taken up by some committee is that of limiting clearances for overhead working conductors on electrified tracks. This is a question which has been under consideration by the electrical section of the engineering division for a number of years and, as chairman of that section, I have repeatedly pointed out that no real progress could be made in establishing normal and limiting heights of an overhead working con-

ductor—trolley wire—without the cooperation of the mechanical division, as the dimensions of rolling stock and attachments are in places affected thereby; furthermore, the cooperation of the operating division is needed in considering the modifications which may, possibly, be necessary in the prevailing practice for employes to ride freight cars. It is evident that the maximum height of the running board of freight cars may influence the minimum allowable height of trolley wire where men are allowed on top of cars under normal conditions, and even in places such as under bridges where men are barred from the top of the cars the minimum height of the wire may be affected by any abnormal height of the brake-staff and wheel. Up to this time no joint action has been taken by the various interested divisions of the Association in establishing standard locations and clearances for overhead contact wires and the need of some concerted action is becoming pressing.

The discussion in Exhibit 2, "Tractive power characteristics of electric locomotives," is very timely, as calling attention to a "time limitation" due to the heating effect of current on the motors in a sustained tractive effort exerted over a considerable period of time. The fact that an electric motor will do more than it is advertised to do without immediately visible signs of distress is a dangerous characteristic which the operating railroad man must be on his guard against taking undue advantage of, or else the repair bill on electric apparatus will mount inordinately with perhaps no visible cause at the time.

Electric traction has enabled, with very advantageous results, substitution of a self-propelling car for a locomotive. This has been done especially in services which require frequent stops and starts and a high average schedule as in suburban runs; the ability of multiple-unit trains to quicken running has remarkable practical advantages in congested operation in terminals as well as in stimulating travel. It should be remembered, however, that in accelerating a train from a stop the energy required is proportionate to the weight lifted into motion and the rate of acceleration on a given grade; the energy-input at the train becomes, therefore, very great under modern requirements and indicates the importance of eliminating all unnecessary weight. As the shocks produced in starting a self-propelled train are much reduced over those with a locomotive-propelled train, there would seem to be an opportunity for a revision of the many features of car design common in steam practice in the direction of lightening draft rigging and underframing, while still maintaining sufficient strength against collision. Furthermore, it would seem to be possible to lighten the superstructure and fittings of the car by using metals which are lighter than steel. This is an important possibility which might be considered generally by car designers.

I have not the space to comment on the Virginian electrification further than to call attention to the innovation adopted in using powdered fuel for the power house boilers. In this installation it was deemed essential to employ some other fuel than lump coal stoked in the ordinary manner, in order successfully to deal with the enormous fluctuations of demand on the boilers caused by the nature of the traffic. In the case of this road the trains are unusually heavy and the number in actual motion at one time and taking current is very few, amounting to perhaps not over three on the entire line and often not over one. Starting one train on the heavy mountain grade requires upwards of 20,000 hp. at the boilers and it can be readily seen that this amount of power coming on or going off suddenly introduces extremely difficult conditions in maintaining and regulating the steam supply to the turbines, also in preventing excessive waste at the safety valves when the load is suddenly reduced. It was deemed necessary in this case to employ either gaseous, liquid or powdered fuel, the supply of which could be instantaneously controlled and it was decided that powdered coal delivered to the boilers by using jets was the most available means of dealing with the situation. While the designers of this installation realized that they were pioneering in an important feature of power house design by using powdered fuel, yet it seemed essential to do so and it is gratifying to be able to state that the results have been remarkably successful. And while economy of fuel consumption was not in this case a primary consideration it has been demonstrated that economical results have been obtained.

J. Purcell (A. T. & S. F.): I make a motion that the paper be received, printed in our proceedings, the committee receive a vote of thanks, and that it be continued with a hope that they will not run the steam locomotive off in the next 10 or 12 years.

(*The motion was duly seconded, and carried.*)

Report of Committee on Locomotive and Car Lighting

W. E. Dunham
Chairman

Inside frosted lamps for general lighting service are now being manufactured in sizes up to and including 100 watts and the satisfaction they are giving will probably cause them to nearly eliminate demand for the many other types now in service. Appendix A of the report lists the proposed line of inside frosted lamps for train-lighting service and also lists the lamps which will be replaced if the new line is adopted. The new line includes eight lamps and if the railroads insist on a 75-watt size, it will include ten lamps. If the new line is adopted it will displace 48 different lamps. The new lamp is generally suited to all types of reflectors and can be used in open type reflectors without causing glare. The frosting is highly efficient and does not affect the life of the lamp and the lamp is easy to clean. While the cost of manufacture is greater than that for a corresponding clear lamp, it should be possible to reduce this cost because many different types will be replaced by a few. Reduction in numbers of types would also affect a marked saving to the railroads by greatly reducing the number of lamps kept in stock.

Electric Lights for Classfication Lamps and Markers on Locomotives and Tenders

After considerable correspondence and conference with the proper committee of the operating division, the necessary cuts were prepared and submitted to that committee for their handling in connection with revision of the standard code of train rules.

Cab, Classification and Marker Lamps

The development of cab, classification and marker lamps is still being carried on by the lamp manufacturers. The committee, at the present time, is not in position to make any definite recommendation as to standards or recommended practices.

For the information of the membership, Appendix A is added to indicate the present standing of the development in lamp design and construction.

Bolt and Screw Thread Standardization

The subject of bolt and screw thread standardization, which was suggested by this committee in connection with construction

of headlight generators, is being covered by the committee on locomotive design and construction, and they are submitting a recommendation in detail to the 1926 convention.

Axle Belt Drive

No immediate or radical change from present practices is contemplated. Opinion appears to be general that a wide-faced axle pulley is desirable, but the most serviceable width, all factors considered, has not been proven. Pulleys of 25-inch face, as well as those of 28½-inch, are giving good results so far as belt life is concerned. It is to be hoped that eventually the pulley design can be improved to simplify its application. Reduction in weight is desirable, as is also a more satisfactory bushing. There is an evident desire for pulley mounted centrally on the axle with a single bushing, the face to be as wide as can be obtained consistent with the clearances and the single bushing support.

Depth of Battery Box

The Association of Railway Electrical Engineers has approved practices of inside dimensions:

Height in clear—24 inches.

Depth from front to back—31 inches.

Length of compartment to hold two standard double-compartment trays—23⅝ inches.

Length of compartment to hold four standard double-compartment trays—3 feet 11½ inches.

The use of boxes having these dimensions makes it possible to flush and inspect 350-ampere hour, 32-volt lead batteries and Edison of equal capacity without removing the crates to gain head room. Sufficient third-rail clearance is provided on other than extremely low car frames.

The committee recommends that these dimensions, which are slightly greater than the present standard of the Association, be submitted to letter ballot for adoption as to standard.

Appendix A—Revision of Tungsten Lamp Standards

Communication from Edwin B. Katte, chief engineer—electric traction, New York Central R. R., New York City, dated June 24, 1925, to the secretary.

"The committee on electricity of the electrical section of the A. R. A. is endeavoring to revise the tungsten lamp standards as contained in the manual of the A. R. E. A. contained in the manual of 1921, page 951, and has a tentative revision thereof, attached hereto, dated June 9th, 1925.

"Will you kindly forward this tentative tungsten lamp standard to the chairman of the appropriate committee of your division, with request that they co-operate with the electrical section with the view of securing one tungsten lamp schedule which may be adopted as standard by the A. R. A.

"The advantage to the railway purchasing agents in having one standard for the purchase of tungsten lamps for all departments is so obvious as to require no further explanation of our efforts in this matter."

Tentative revision of tungsten lamp standards by American Railway Engineering Association, as of June 9, 1925.

(Illumination)

Size in Watts	Voltages	Type and Size of Bulbs	Base		Type	Remarks
10	110, 115, 120, 125	S–14	Med.	Sc.	B	
15	" " " "	S–17	"	"	B	
25	" " " "	S–17	"	"	B	
40	" " " "	S–19	"	"	B	
50	" " " "	S–19	"	"	B	
75	" " " "	PS–22	"	"	C	
100	" " " "	PS–25	"	"	C	
150	" " " "	PS–25	"	"	C	
200	" " " "	PS–30	"	"	C	
250	" " " "	G–30	"	"	C	Floodlighting
300	" " " "	PS–35	Mogul	"	C	
500	" " " "	G–40	"	"	C	
500	" " " "	PS–40	"	"	C	
750	" " " "	PS–52	"	"	C	
1000	" " " "	PS–52	"	"	C	

Size in Watts	Voltages	Type and Size of Bulbs	Base		Type	Remarks
25	220, 230, 240, 250	P–19	Med.	Sc.	B	Coil Filamen
50	" " " "	P–19	"	"	B	"
100	" " " "	PS–25	"	"	C	
200	" " " "	PS–30	"	"	C	
300	" " " "	PS–35	Mogul	"	C	
500	" " " "	PS–40	"	"	C	
750	" " " "	PS–52	"	"	C	
1000	" " " "	PS–52	"	"	C	

Mill Type

25	110, 115, 120, 125	P–19	Med.	Sc.	B	Coil Filament
50	" " " "	P–19	"	"	B	"

Car Axle Lighting

15	30 to 34, 60 to 65	S–17, G–18½	Med.	Sc.	B	
25	" "	S–17, G–18½	"	"	B	
25	" "	PS–18	"	"	C	Frosted
50	" "	S–19, G–30	"	"	B	
50	" "	PS–16, PS–20	"	"	C	Frosted
75	" "	PS–22	"	"	C	"
100	" "	PS–25	"	"	C	"

Motor and Trailer Car and Locomotive Lighting and Headlights

15	33	S–17	Med.	Sc.	B	Cab Lighting
23	110, 115, 120, 125, 130	S–17	"	"	B	Series
36	" " " "	S–19	"	"	B	"
56	" " " "	S–21	"	"	B	"
94	" " " "	S–24½	"	"	B	"
100	32	G–25	"	"	C	Headlight
150	32	6–25	"	"	C	"
250	23	G–30	"	"	C	"

Communication from E. W. Jansen, electrical engineer, Illinois Central R. R., Chicago, dated Oct. 19, 1925 to the Secretary.

"Referring to your letter of the 6th inst. sending copy of letter from chief engineer, electric traction, Mr. E. B. Katte of the New York Central, in regard to revising the list of tungsten lamps, as contained in manual of the A. R. E. A. of 1921.

I have gone over this list which was revised June 9, 1925, and would suggest that following the 15th item, we insert 1000 watt, 115 volt G-40 Mogul socket, type "C" coil filament flood light lamp.

In the new 23-in. glass reflector flood lights, we now install, we are using the G-40, 1000 watt type "C" coil filament lamp.

In car lighting lamps, after the 3rd item, we should add 25 watt, 32 volt PS-16 medium screw base, type "C" clear lamps.

The lamp manufacturers are now trying to standardize on a new type bulb to be called the "A" bulb, being a combination of the pear-shape bulb and the standard straight side bulb, the bulb appearing to be the shape of a top.

The lamp manufacturer should be consulted as to just what type of bulb he expects to furnish in the future on different sizes of lamps, type of lamps, whether "B" or "C," etc., on list of the A. R. E. A. On the Illinois Central we prefer the coated type of bulb instead of the exterior frosted type as the latter becomes soiled more easily."

Communication from A. L. Broe, commercial engineering section, Edison Lamp Works, dated March 10, 1926, to the chairman.

In view of your position as chairman of the committee on locomotive and car lighting of the American Railway Association, I wish to bring to your attention certain recent developments in the train-lighting line which possibly you are already familiar with.

The Mazda lamp manufacturers have recently placed on the market a new line of Mazda trainlighting lamps both in the 30-34 and the 60-65 volt ranges. The primary purpose of this new line of lamps is to effect simplification in the standard line of Mazda lamps. It was felt that in the old line of Mazda lamps there was a greater diversity of bulbs and finishes than the service really required.

To cite one example, the 25 watt trainlighting lamp was made in the S-17, G-18½, and PS-16 bulbs, and each furnished in three finishes, clear, bowl frosted and all frosted, or in other words, a total of 9 varieties of 25 watt lamps. A new bulb has been designed with the view of combining in one type the principle advantages of these various types together with other progressive improvements. The new bulbs are all frosted on the inside, which provides a means of diffusion better than any possible up to the present time. The light absorption of the inside frosting is very low, only 1 to 2 per cent, and from the standpoint of ease of cleaning it is of course the equal of the clear lamp. The candle-power maintenance during life is equal to the clear lamp and superior to that of any outside frosted or coated lamp.

We are hopeful that through the advantages to all concerned in the use of these new lamps, they will largely replace all of the existing types within the ranges mentioned, thus effecting a material reduction in the number of standard types.

This program of simplification, we believe, to be of great economic advantage. It is directly in line with the policy of the Department of Commerce, under whose direction many branches of industry have already taken similar action.

All of the new trainlighting lamps are of the Mazda C (gas-filled) construction except the 15 watt, 60-65 volt lamp which is a Mazda B (vacuum lamp), and will be efficient as the corresponding old types of Mazda C lamps in the PS bulbs, and more efficient than the corresponding sizes of Mazda lamps in the S and G bulbs.

I am enclosing herewith a copy of our price schedule, on page No. 9 of which you will find the new trainlighting lamps listed. I am also enclosing copy of the manufacturer's schedule, giving the technical ratings and detailed specifications of these lamps. I also enclose a table showing comparisons of the dimensions of the new and old bulbs, and blueprints showing the comparisons of the shapes of the new and old bulbs.

I believe this subject would be worthy the careful consideration of your committee, with the view to adopting these new lamps as

A. R. A. standards. If you wish any additional copies of the enclosures to distribute to the other members of your committee, I will be very glad to furnish you with any number required.

New Train Lighting Range
30-34 Volt Range

Proposed Line				Replaces			
Watts	Bulb	Light Center	Max. Overall	Watts	Bulb	Light Center	Max. Overall
15	A-17	2 3/16"	3 3/16"	15	S-17	3"	4 5/16"
					G-18 1/2	2 3/16"	3 3/16"
					PS-16	2 3/16"	3 5/16"
25	A-19	2 1/2"	3 5/16"	25	S-17	3"	4 5/16"
					S-18 1/2	2 3/16"	3 5/16"
					PS-16	2 5/16"	3 5/16"
50	A-21	3 3/16"	4 5/16"	50	PS-20	3 3/4"	5 5/16"
100	A-23	4 1/16"	6 1/16"	75	PS-22	4 1/16"	5 7/16"
					PS-25	5 1/16"	6 5/16"

60-65 Volt Range

15	A-17	2 3/16"	3 3/16"	15	S-17	3"	4 5/16"
					G-18 1/2	2 3/16"	3 3/16"
25	A-19	2 1/2"	3 5/16"	25	S-17	3"	4 5/16"
					G-18 1/2	2 3/16"	3 3/16"
50	A-21	3 3/16"	4 5/16"	50	PS-20	3 3/4"	5 5/16"
100	A-23	4 1/16"	6 1/16"	75	PS-22	4 1/16"	5 7/16"
				100	PS-25	5 1/16"	6 5/16"

The report is signed by W. E. Dunham (chairman) superintendent car department, Chicago & Northwestern Railway; E. Wanamaker, electrical engineer, Chicago, Rock Island & Pacific Railway; A. E. Voight, car lighting engineer, Atchison, Topeka & Sante Fe Railway; J. L. Minick, assistant engineer, Pennsylvania Railroad System; W. H. Flynn, superintendent motive power, New York Central Railroad; E. W. Jansen, electrical engineer, Illinois Central Railroad; E. Lunn, electrical engineer, The Pullman Company.

Discussion

J. H. Minick (Penna.): Since sending the letter to the Mechanical Division, which is included in the report, a second letter has been received from Mr. Katte in which he withdraws the schedule contained in this publication and submits a new schedule. The new schedule covers the so-called inside frosted bulb lamps of the A type. These lamps are rather a new development and are offered by lamp manufacturers as a means of greatly reducing the large variety of lamps now manufactured for regular use. The reduction will be from 50 to 75 per cent in the variety of lamps available. These lamps, while they are now on the market to some extent, have not yet been fully proven out in service and it may be possible that their design will be changed and modified slightly and the electrical section of the Engineering Division has taken action favoring the development or revision of the existing schedules, but has not actually approved the new schedule offered.

L. S. Billau (B. & O.): Incandescent lamp manufacturers have now placed the 15-watt, 33-volt, S-14 bulb lamps for locomotive cab lighting service in their regular schedule of lamps with expectation that it will supersede the 15-watt lamp in the S-17 bulb. As the new lamp possesses a number of advantages over the present lamp, it would seem desirable that the association take action relative to adopting this lamp as recommended practice.

The 100-watt and the 250-watt locomotive headlight lamps are now both manufactured in the P-25 bulb which is bound to result in confusing the lamp for switching locomotive service with that for road locomotive service unless some satisfactory means of marking one of the lamps is adopted which will permit readily identifying them. In this connection it has been suggested that the 100-watt lamp for switching locomotive service be furnished with an inside frosted type of bulb. Samples of this type of lamp have been tried out by one or two roads with satisfactory results, resulting in reduction of glare and better diffusion of the light which are desirable features for switching locomotive service. It is suggested the committee investigate the possibilities of this type of lamp with a view to reaching a decision as to its suitability as standard for this class of service.

The new simplified line of train lighting lamps in the A type of bulb have now been regularly placed on the market by the lamp manufacturers and will automatically supersede the present line as manufacturing facilities become available and stocks of old lamps become exhausted. It would therefore seem desirable that the association take action relative to adopting new line of lamps as recommended practice in place of the existing line of lamps.

With reference to the letter from Mr. Jansen suggesting including the 1,000-watt, G-40 bulb, Mazda C lamp as a standard lamp for flood lighting service, I would advise that the Committee on Illumination of the Association of Railway Electrical Engineers is making a special study of the subject of the flood lighting of railroad yards this year in which connection it is investigating in conjunction with the lamp manufacturers the question as to whether or not a special lamp is necessary to meet the requirements for modern flood lighting facilities and if so to decide upon the best type of lamp that should be developed for this purpose. It therefore seems unwise at this time to select any particular lamp as a recommended standard for flood lighting service.

C. G. Juneau (C. M. & St. P.): I have been looking into the question of pulleys for some considerable time and have arrived at the conclusion that the 14-in. pulley with the 2-in. flange is a happy medium, and placing it as close to the center line of the car as possible will overcome a considerable amount of the belt loss which seems to be the most expensive part of the drive.

In connection with the battery boxes as mentioned the heighth as laid down by the committee provides a suitable condition, but if the figures were to be followed out on some of the older equipment, it would be almost impossible on account of the underframe construction.

Mr. Juneau then read the following prepared discussion on this topic.

[Note: On account of make-up conditions it was impossible to include Mr. Juneau's important addition to the discussion in today's issue. It will, however, appear in the next *Daily* Edition of the *Railway Age,* June 17. —Editor.]

Mr. Minick: Mr. Katte's letter calls for a reply by this division and I therefore move you as follows: That in reply to Mr. Katte's letters of June, 1925, and May, 1926, the Electrical Section of the Engineering Division of the American Railway Association be advised that the Mechanical Division favors a revision of the existing schedules of incandescent lamps which will greatly reduce the large variety of incandescent lamps now regularly manufactured.

The motion was duly seconded and carried The fifth session adjourned.

Conventionalities

(*Continued from Page* 1852)

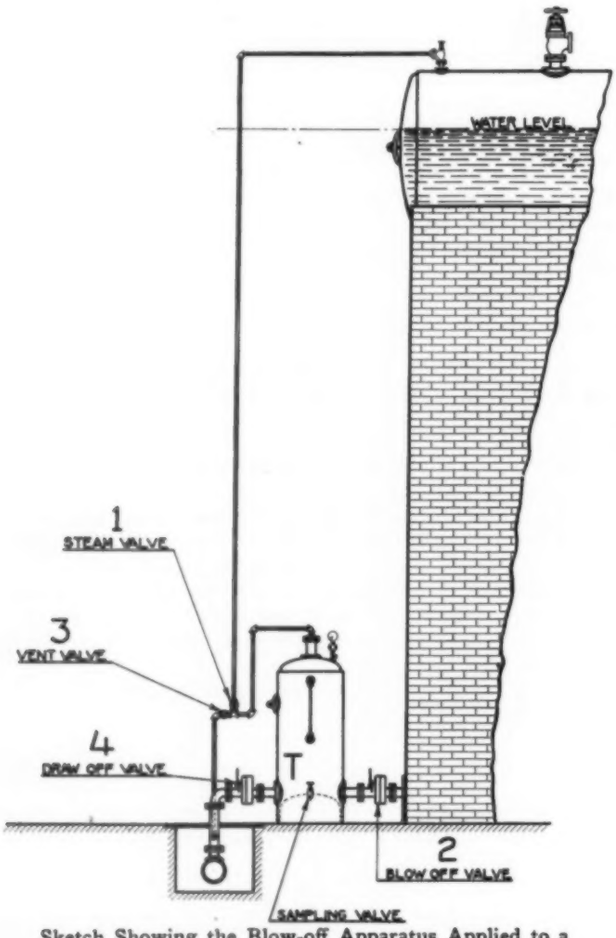
J. H. Cooper, who is now in charge of the Chicago office of the Pilliod Company, had to hurry to get to the conventions because he was recently on a trip over the Mexican railways. Mr. Cooper was formerly with the Pullman Company.

B. B. Greer, president, and J. H. Watters, general sales manager, of the New York Air Brake Company, have been attending the conventions. This is their first attendance since taking their present positions. Mr. Greer until last winter was chief operating officer of the Chicago, Milwaukee & St. Paul.

New Devices

Wylie Wilson Boiler Drawoff Process

THE Everlasting Valve Company, Jersey City, N. J., is exhibiting diagrammatical drawings showing the application of the Wylie Wilson patented boiler drawoff process which can be used on both stationary and locomotive boilers. The system consists of a closed drawoff tank suitable for full boiler pressure, which is interposed between the boiler blowoff valve and the discharge valve to the sewer. The blowoff water drawn off from the boiler passes into the drawoff tank and when a predetermined amount of water has been drawn off, at a



Sketch Showing the Blow-off Apparatus Applied to a Stationary Boiler

predetermined velocity of flow, the discharge from the boiler automatically ceases. The water is then withdrawn from the tank, preferably not at boiler pressure but at a greatly reduced pressure.

The advantages of blowing off slowly are recognized, but the difficulty has been the resultant rapid wearing out of the blowoff control valve. With this process and apparatus, it is claimed that blowing off may be done at any speed desired without harm to the blowoff apparatus.

It now becomes possible for the engineman not only to predetermine the speed at which the water is blown off, but to find out which speed gives the best results. It also becomes possible for him to find out just how the water ought to be blown at each blowoff operation to produce the effect he wishes on the boiler. He not only can find out those things and predetermine the volume and velocity, but can set the apparatus so that when the blowoff valve is opened the blowoff takes place at precisely the predetermined speed and, when the predetermined volume has been blown off, flow automatically stops without shock.

Blowoff at the most efficient velocity means a minimum amount of hot water discharged. Ability to determine just how much water it is necessary to blow diminishes the amount of hot water discharged. Samples of boiler water are readily obtainable at any time for observation of analysis, either to check the effect of water treatment or to observe any corrosion effects.

The drawing shows the stationary boiler application. To operate the apparatus, vent valve 3 and drawoff valve 4 are shut. Then with all the valves closed, the steam valve 1 is opened and the tank *T* put under boiler pressure. Blowoff valve 2 is then opened to balance the pressure. Tank *T* is allowed to fill with water from the boiler, which water flows out only under gravity head pressure and at the consequent velocity until the water fills the tank and rises in the steam pipe to the level of the water in the boiler where it automatically comes to rest. Blowoff valve 2 and steam valve 1 are, respectively, shut under still water and steam. The vent valve 3 is then opened to atmosphere and the pressure of tank *T* is reduced to atmospheric pressure. The drawoff valve 4 is then opened and the water runs to discharge, which completes the cycle of operation.

Improvements in Air Pump Details

THE New York Air Brake Company, New York, is showing among other things several details and accessories for air brake steam-driven compressors, the design of which has been recently improved. These are of particular interest to those having direct concern in the maintenance of locomotive air brake equipment.

An improved method of fastening the steam piston to the rod is shown in section. This gives a stronger connection than any previously employed and consequently will assist in the reduction of air compressor failures. In this design the thread, formerly employed for attaching the piston to the rod, has been replaced by a taper fit; while the steam end of the rod has been enlarged to give a wide bearing surface against the face of the piston. Enlarged tappet plate bolts securely fasten the steam piston to the rod. This construction is adapted to steam

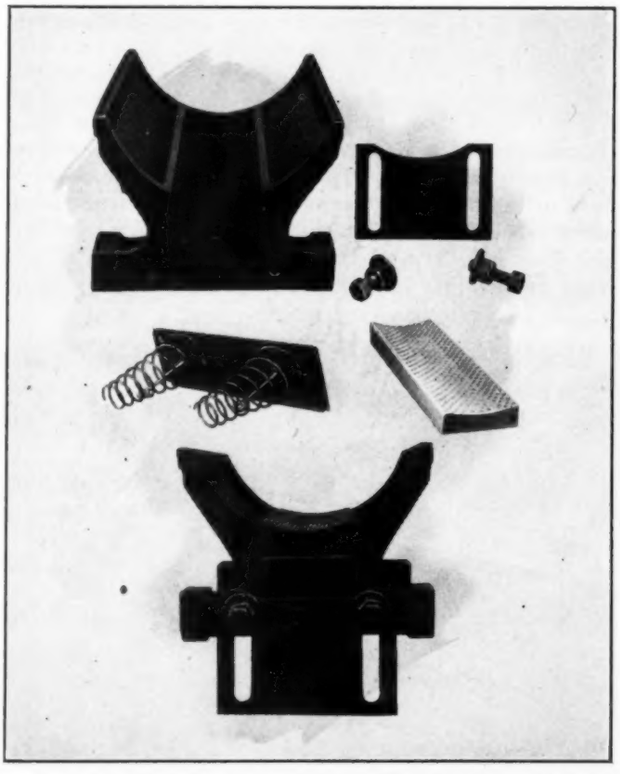
pistons and rods of all forms of steam driven air compressors. A minor change, but one which will be of considerable convenience to those who maintain air compressors is a modification in piston ring practice. The rings now furnished are made of a special metal, developed after considerable research and many tests, to give great efficiency and durability. The design and methods of manufacture are such as to insure uniform tension and close contact with the cylinder walls. The rings are ground on the sides to the proper thickness and, furthermore, are re-turned after being closed on the outside to the exact diameter of the cylinder bore. This leaves only a few thousandths of an inch in diameter to be taken care of when the rings are applied, thus insuring a more efficient ring and a reduction in the cost of application.

The oil atomizing lubricator for air compressors has been simplified and improved in several details of construction, although the general principle remains the same. The recognized importance of air compressor lubrication makes a device of this sort of vital importance.

Another air compressor accessory that has been improved in details of construction is the centrifugal air pump strainer. The improvements can best be observed by looking at the sectional samples.

The Economy Driving Box Grease Cellar

ONE of the new developments being exhibited at the booth of the American Locomotive Company, 30 Church St., New York, is the Economy driving box grease cellar. Referring to the illustration, the block of grease is placed on the top of a follower plate



Driving Box Grease Cellar Designed to Provide Uniform Lubrication and Prevent Waste of Grease

and is held in place by a perforated plate. The follower plate is supported by two springs, the compression of which pushes the grease block and perforated plate up against the journal. The perforated plate is constructed in a substantial manner to prevent distortion or mutilation when replenishing cellars. The end plate, which is shown at the top of the illustration, is adjustable. It is held in place by two bolts, and it is only necessary to remove the nuts on the bolts to examine or repack the grease cavity. The cellar is constructed of cast steel which not only permits a reduction in weight, but increases its strength. No special work is required on the driving box brass to apply the Economy cellar, as it is grooved and fitted in the usual manner. Waste of grease is eliminated, as the grease is fed no faster than it is used by the journal. A lower running temperature is maintained on the journals due to better lubrication and the air cooling features of the device. Cooler running insures longer life of the bearings.

Recording Device for Mounting of Car Wheels

THE Ashton Valve Company, Boston, Mass., is exhibiting a recording device, the object of which is to provide means for actuating the chart recording device so that when used with a double ram wheel press they will record actual values of each wheel independent of the other though they are mounted at the same time. This device has been patented by Russell G. Henley and Barnard Cook of the Norfolk & Western.

Means have been provided for actuating the recording device whereby the record made represents the movement of the wheel relative to the axle, irrespective of the movement and axle relative to the frame of the press. The recording devices, which may be seen at the extreme

Details of the Fixed and Movable Arms of the Recording Device

left and right sides of one of the illustrations, are mounted either on or off the frame of the press. The pressure exerted by the press rams is transferred to and recorded by the recording device in the usual way. The movement of the wheel relative to the axle is recorded as follows:

Mounted on each of the ram shoes are two arms, one of which is adjustably fixed relative to the ram shoe, and the other is free to move relative to the shoe. Permanently secured to the shoes are two supports which locate the guides of the device. These guides are secured to a fixed arm and a movable arm. The fixed arm is provided with suitable means of clamping it at any desired

location along the guides. The movable arm is mounted so that it is free to move along the guides and extends down through an opening in the ram shoe and comes in contact with the end of the axle. Mounted on one end of each of the two arms are grooved wheels, over which is fitted a steel cable in such a manner that the distance between the ends of the cable is changed by the movement of the movable arm relative to the fixed arm. One end of the cable is secured to some fixed part on the press and the other to a lever on the recording device.

In mounting the wheels, the fixed arms are so located on the guides by means of bolts that when each wheel is just beginning to move onto its axle seat, the lower ends of the movable arms will be in contact with the ends of the axle and the recording device will be at zero. As the wheels move up to their seats, the two arms move farther apart and the distance between the ends of the wire cables is changed, which actuates the recording device.

The Actuating Device Which Operates the Two Recording Charts is Mounted on Each of the Ram Heads

Filler blocks are recessed so that the ends of the movable arms will not interfere with the ends of the axle coming in contact with the filler blocks, which contact limits the total movement of the wheels on the axle.

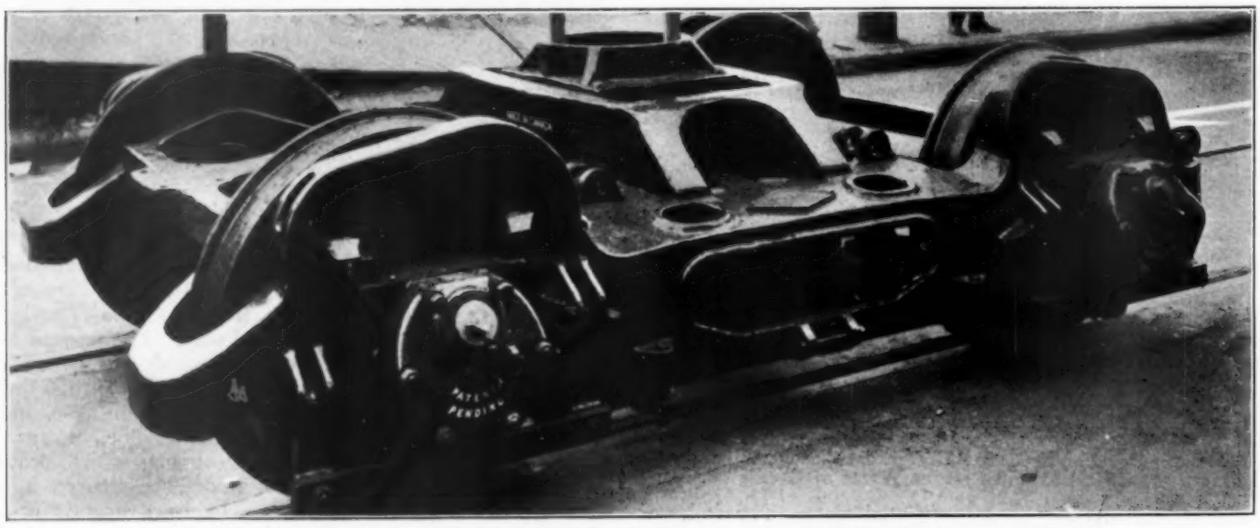
Should either wheel move with the axle relative to the other wheel, which does occur, the cable rollers in the arms will move along the cable, but will not change the distance between its ends and such movement will not be recorded by the recording device. Between the fixed and movable arms is a spring which returns the movable arm to its normal position and allows the recording device to return to the zero reading when the axle and mounted wheels have been removed from the press. Other means, such as weights, may be employed to accomplish this.

Engine Truck with Outside Journals

INCLUDED with the track exhibit is an outside journal four-wheel engine truck built by the Canadian Locomotive Company for the Canadian National. The bearings of this truck are of the bronze floating bushing type which are lubricated by grease. The main truck frame is a one-piece steel casting designed and made by the Commonwealth Steel Company, Granite City, Mo. The swing bolster is of the Woodward constant resistance type. While the truck is not fitted with brakes, provisions have been made for them, the application of which would be of a simple design.

A study of the design of the truck frame casting shows how the cylinder clearance has been obtained. The only alteration it was necessary to make in the first application was to the cylinder cock operating rod. As a rule, this alteration would apply to any locomotive having a truck wheel base of approximately 80 in.

The first of these trucks has been in service for about 18 months under a Mountain type locomotive used in fast passenger service. The real reason for the development of the truck was the increase of engine truck lubrication trouble when locomotives were operated over several divisions. The boxes on this truck were sealed and given no attention for 7,000 miles, during which time no trouble whatever was experienced.

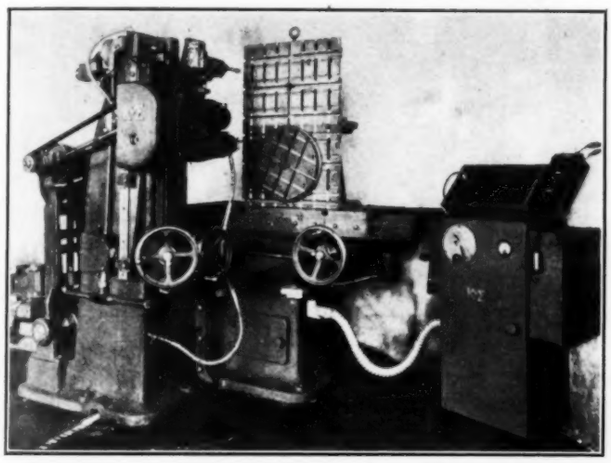


Outside Journal Engine Truck Equipped with Grease Lubricated Floating Type Bearings

Automatic Machine for the Tool Room

THE Keller Mechanical Engineering Corporation, 70 Washington street, Brooklyn, N. Y., is exhibiting its type BL automatic tool room machine which is designed to meet the requirements of the die and tool room, and the metal pattern shop. It is especially adapted to the production of dies for blanking, trimming, embossing, forming, punching, forging and molding punches, pressure pads, cams, templates, gages, jigs, form cutters, metal core-boxes, patterns, match plates and also to a variety of general machining which presents difficulties when handled on conventional machine tools. Drilling, plain or face milling, jig boring, reaming, gear cutting, etc., can also be conveniently performed on this machine.

The machine is equipped with a full-automatic control for cutting cavities or reliefs from a master template or guide. The master may be made of easily molded or



Machine Designed for the Production of Dies and Similar Work

shaped material such as lead, cement, plaster, or wood. For cutting blanking dies, punches, or other contouring jobs, the master may be a thin sheet metal template, a previously made part or tool having the correct outline. Differences in dimensions can be taken care of by proportionate variations in the relative sizes of the tracer and cutter.

The operator has the choice of full-automatic or semi-automatic electrical control and also of hand-wheel operation. Hand wheels are provided for manual operation of all movements. A push-button attached to a flexible cord is provided for hand control of contouring operations. The operation in this case continues as long as the button is pressed and heavy as well as the most delicate cutting may be taken care of in this manner.

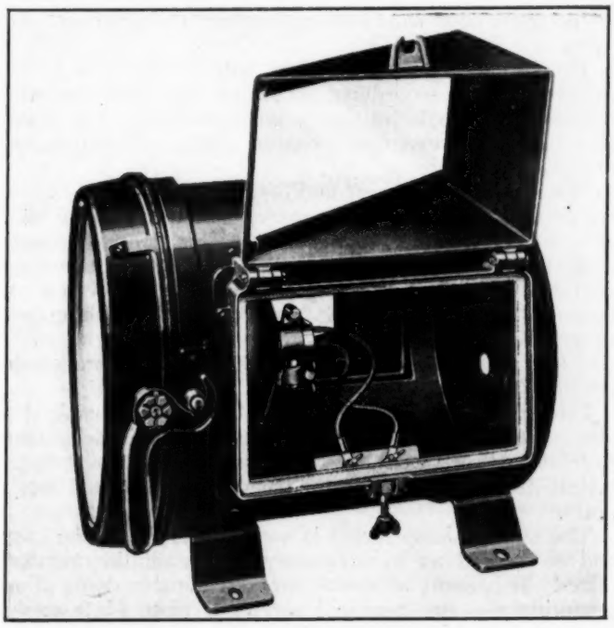
The electrical control is concentrated in a push-button panel on a heavily constructed steel cabinet, which contains the main switches, automatic starter, reversing switch, control relays, voltmeter, and rheostats for the motor generator unit. This arrangement enables the operator to control all movements of the machine from one position.

The vertical mounting of the work facilitates the removal of chips by a stream of lubricant, which is forced directly to the cutting point through two nozzles. High speeds are permitted by this high pressure cooling system and the cutter is kept free from chips, without regard to depth of cut or space restrictions.

The machine is fully self-contained. Each movement has its individual drive unit, actuated, by a variable speed motor, mounted at the end of its respective lead screw. The spindle drive is through wide belts, running on four-step ball bearing cone pulleys. It has a separate 2-hp. motor mounted on the machine bed. Correct belt tension is maintained through a simple turnbuckle device. An overarm is supplied which is rigidly clamped on the saddle bearing. The arbor is inserted in the spindle in the usual way and can be supported either at the end or anywhere along its length. Micrometer stops can be supplied for jig boring and provisions for the stops are made in the table and column. Such operations as cutting cavities, reliefs and contours, drilling, facing, plain milling, can be done at one setting by changing the cutters.

Glass Reflector Headlight in Rust Proof Steel Case

A GLASS reflector headlight in a rust-proof case is now being made by the Sunbeam Electric Manufacturing Company, Evansville, Ind., which is designed to meet the three essentials of a locomotive headlight, namely, adequate illumination, long life and minimum maintenance. With a standard 250-watt lamp, the manufacturer states, the headlight produces over 600,000 beam candle power.



Sunbeam Rust-Proof Headlight, Type 4414-B With Number Door Open Exposing Focusing Device and Terminals

The headlights are made in three types. Type 4414, has the side number plates parallel to the center line of the locomotive. Type 4414-A has a side hand-hole but no number plates. Type 4414-B has the side number plates on a 30 degree angle. In all other details the headlights of this type, known as the 4400 series, are identical. All types are made with visor if desired.

Rust-proof steel, 16 gage, is used for the case and back. Claim is made for the case that it shows no corrosion when exposed, unpainted, to atmospheric conditions in the roundhouse or on the road and that it has 50 per cent

greater strength than ordinary steel. Thus in addition to providing protection against atmospheric corrosion it also provides additional strength to resist rough handling and abuse.

All joints in the headlight case are welded. The back is flanged and welded to the case. The legs are made of ⅜-inch by 2-inch wrought iron. The reflector is made of amber tinted glass ground to a parabolic curve on front and back. It is 14 in. in diameter and has a focal length of 3¼ in. A chemical deposit of pure silver is made on the back of the reflector which in turn is protected by a copper electroplate and several coats of special paint. The reflector is then mounted in a felt lined, rust-proof steel back pressed to the same shape as the reflector. This metal back securely holds the reflector, prevents breakage and protects the silvering against damage while the lamp is being inspected or focused. The reflector retaining ring is also made of rust-proof steel. A clear crystal glass reflector can be furnished if desired.

The front door is a heavy casting. It provides a rigid bearing for the front glass and a tight joint against the case. Between the case and the front door heavy jute packing insures a weather tight seal. To maintain this seal indefinitely a malleable iron front door latch is used with adjustment to compensate for packing shrinkage. This is accomplished by means of an eccentric latch pin bushing having sufficient adjustment to insure a tight joint at all times.

The front door hinge pins are made of ½-in. brass and secured to the case. This permits lifting the door from the case without removing the pins. Heavy glass is used in the front door with packing between the glass and the door.

The headlights are furnished with a visor, as extra equipment when so ordered. Because it reduces the light reflected on signals its use is recommended. The visor also facilitates reading of engine numbers from signal towers.

The side number frame and door are cast metal. They are applied either parallel to the case or in the Type "B" at a 30 degree angle to the case. This door is hinged at the top and arranged so that the entire extension swings up making the terminals easily accessible. Jute packing between the side door and frame and cork packing between the door and glass insures a weather tight joint. The side number door latch consists of a heavy brass bolt with an iron wing nut.

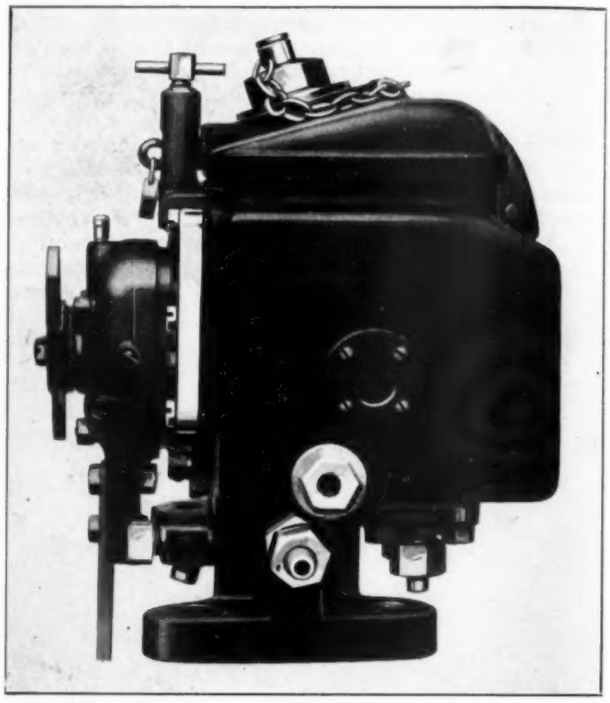
Universal movement is provided by the focusing device, pattern 10, regularly furnished with this headlight. Lateral and vertical adjustment is easily made and is maintained by wing nuts. All parts are made of heavy brass.

The number lamp socket is mounted in top of the case and so located as to adequately illuminate the number plates. It is easily accessible through the side door. For mounting the two terminal screws a plate is fastened under the side door frame. This plate and terminals are easily accessible through the side door.

Valveless Mechanical Locomotive Lubricator

THE D. V. type of valveless mechanical lubricator which has recently been somewhat modified is being exhibited by the Nathan Manufacturing Company, 250 Park Avenue, New York. The principal difference in design is that in the older types the cover lifted on the long axis of the lubricator, while on the type being exhibited the cover lifts on the short axis so that much less space is required for lifting up the cover. In addition a filling plug has been added which is attached to the lid by a chain to prevent it from becoming lost.

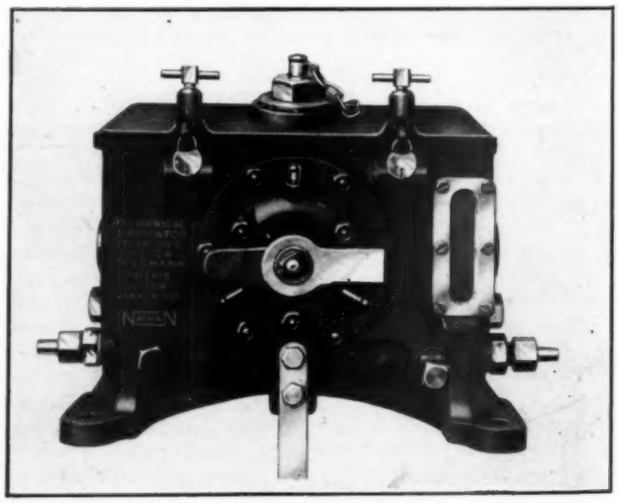
The older type of lid had no means of preventing the cover from being opened as it was only held in place by



Side View Showing the Redesigned Lid and Filling Plug

two wing nuts. The new type contains two sealing lugs which consist of a lock screw and handle which is screwed down through a yoke against the lug for sealing the cover. A small lock is passed through each lug, thus preventing any one from opening the cover except those responsible for maintenance.

Another difference is in the method of attaching the



The Nathan Lubricator, with a Sealed Cover and Attached Filling Plug

ratchet mechanism, which in the new types is accomplished by means of a flange accessible from the outside so that the whole ratchet mechanism may conveniently be removed and replaced as a complete unit for purposes of inspection and repairs.